EAST WATERWAY OPERABLE UNIT
SUPPLEMENTAL REMEDIAL INVESTIGATION/ FEASIBILITY STUDY
FINAL QUALITY ASSURANCE PROJECT PLAN
BENTHIC INVERTEBRATE TISSUE/GASTROPOD COLLECTION

For submittal to:

The US Environmental Protection Agency
Region 10
Seattle, WA

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Prepared by:

Wind Ward environmental LLC

200 West Mercer Street • Suite 401
Seattle, Washington • 98119

EAST WATERWAY BENTHIC INVERTEBRATE TISSUE/ GASTROPOD COLLECTION
FINAL QUALITY ASSURANCE PROJECT PLAN

APPROVALS

Windward Project Manager	Susan M'Gonigle Name	1/6/09 Date
Windward QA/QC Manager	[signature] Name	1/6/09 Date
EPA Project Manager	[signature] Name	1/22/09 Date
EPA QA Officer	[signature] Name	02/09/09 Date

Distribution List

This list identifies all individuals who will receive a copy of the approved quality assurance project plan, either in hard copy or electronic format, as well as any subsequent revisions.

- Ravi Sanga, EPA Project Manager
- Ginna Grepo-Grove, EPA QA Manager
- Susan McGroddy, Windward Project Manager
- Nancy Musgrove, Windward Task Manager
- Helle Andersen, Windward Field Coordinator
- Marina Mitchell, Windward QA/QC Manager

Chemistry Project Managers:

- Sue Dunnihoo (Analytical Resources, Inc.)

East Waterway Group:

- Doug Hotchkiss, Port of Seattle
- Debra Williston, King County
- Jeff Stern, King County
- Peter Rude, City of Seattle

Subcontractors:

- Dave Mullins, Mullins Guide Service
- Charlie Eaton, Bio-Marine Enterprises
- Alan Kohn, University of Washington

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Acronyms

ACRONYM	Definition
%RSD	percent relative standard deviation
ACG	analytical concentration goal
ANSETS	Analytical Services Tracking System
ARI	Analytical Resources, Inc.
CFR	Code of Federal Regulations
COC	chain of custody
COI	chemical of interest
CVAA	cold vapor atomic absorption
DCM	dichloromethane
DGPS	differential global positioning system
DQI	data quality indicator
DQO	data quality objective
EPA	US Environmental Protection Agency
ERA	ecological risk assessment
EW	East Waterway
EWG	East Waterway Group
FC	field coordinator
FS	feasibility study
GC/ECD	gas chromatography/electron capture detection
GC/FPD	gas chromatography/flame photometric detection
GC/MS	gas chromatography/mass spectrometry
GC/MS/MS	gas chromatography/mass spectrometry/mass spectrometry
GFAAS	graphite furnace atomic absorption spectrophotometry
HAZWOPER	hazardous waste operations and emergency response
HDPE	high-density polyethylene
HG-AFS	hydride generation-atomic fluorescence spectrometry
HRGC/HRMS	high-resolution gas chromatography/high-resolution mass spectrometry
HSP	health and safety plan
ICP-AES	inductively coupled plasma-atomic emission spectrometry
ICP-MS	inductively coupled plasma-mass spectrometry
ID	identification
LCS	laboratory control sample

ACRONYM	Definition
LDW	Lower Duwamish Waterway
MDL	method detection limit
MSA	method of standard additions
MS	matrix spike
MSD	matrix spike duplicate
NAD 83	North American Datum 1983
NOAA	National Oceanic and Atmospheric Administration
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PM	project manager
PSEP	Puget Sound Estuary Program
QA/QC	quality assurance/quality control
QAPP	quality assurance project plan
RL	reporting limit
ROC	receptor of concern
RPD	relative percent difference
RPS	relative penis size
SDG	sample delivery group
SMS	Washington State Sediment Management Standards
SRI	supplemental remedial investigation
SRM	standard reference material
SVOC	semivolatile organic compound
TBT	tributyltin
TM	task manager
TOC	total organic carbon
Windward	Windward Environmental LLC

1 Introduction

This quality assurance project plan (QAPP) describes the sampling design and quality assurance objectives and protocol for collecting benthic invertebrate tissue and co-located surface sediment necessary to characterize the chemical concentrations associated with exposure of benthic invertebrates and their predators to contaminants in the East Waterway (EW). Gastropods (i.e., snails) will also be collected in the EW in a separate effort for an evaluation of imposex and intersex as a measure of exposure and effects associated with tributyltin (TBT), one of the chemicals of concern for the EW. Details about project organization and management, field data collection methods, sample handling, laboratory analytical protocols, and data management and documentation are also provided. This QAPP was prepared in accordance with guidance for preparing QAPPs from the US Environmental Protection Agency (EPA, 2002).

Two benthic invertebrate studies are described in this QAPP:

- Collection and chemical analysis of invertebrate tissue samples and co-located surface sediment samples
- Collection of prosobranch gastropods and evaluation of imposex and intersex stage in female snails

Data from these studies will be used to support the ecological risk assessment (ERA) for the supplemental remedial investigation (SRI) and feasibility study (FS) for the EW. This QAPP is organized as follows:

- Section 2 – project management
- Section 3 – data generation and acquisition
- Section 4 – assessment and oversight
- Section 5 – data validation and usability
- Section 6 – references
- Section 7 – maps

A health and safety plan (HSP) designed for the protection of onsite personnel from physical, chemical, and other hazards posed during field sampling activities is included as Appendix A. Field collection forms are included as Appendix B. The derivation of risk-based analytical concentration goals (ACGs) for invertebrate tissue is presented in Appendix C. The derivation of ACGs for sediment collected at benthic invertebrate sampling locations is presented in Appendix D. Data management procedures are presented in Appendix E. Gastropod imposex/intersex observation forms are provided in Appendix F.

2 Project Management

This section describes the overall management of the project, identifies key personnel, and describes their responsibilities, including field coordination, quality assurance and quality control (QA/QC), laboratory management, and data management.

2.1 PROJECT ORGANIZATION AND TEAM MEMBER RESPONSIBILITIES

The East Waterway Group (EWG), which is composed of the Port of Seattle, City of Seattle, and King County, and EPA will be involved in all aspects of this project, including discussion, review, and approval of the QAPP and the interpretation of the results of the investigation. Windward Environmental LLC (Windward) will be responsible for the management and implementation of the effort described in this QAPP and coordination with EPA and the EWG. Figure 2-1 shows the overall project organization for the benthic invertebrate tissue collection described in this QAPP.

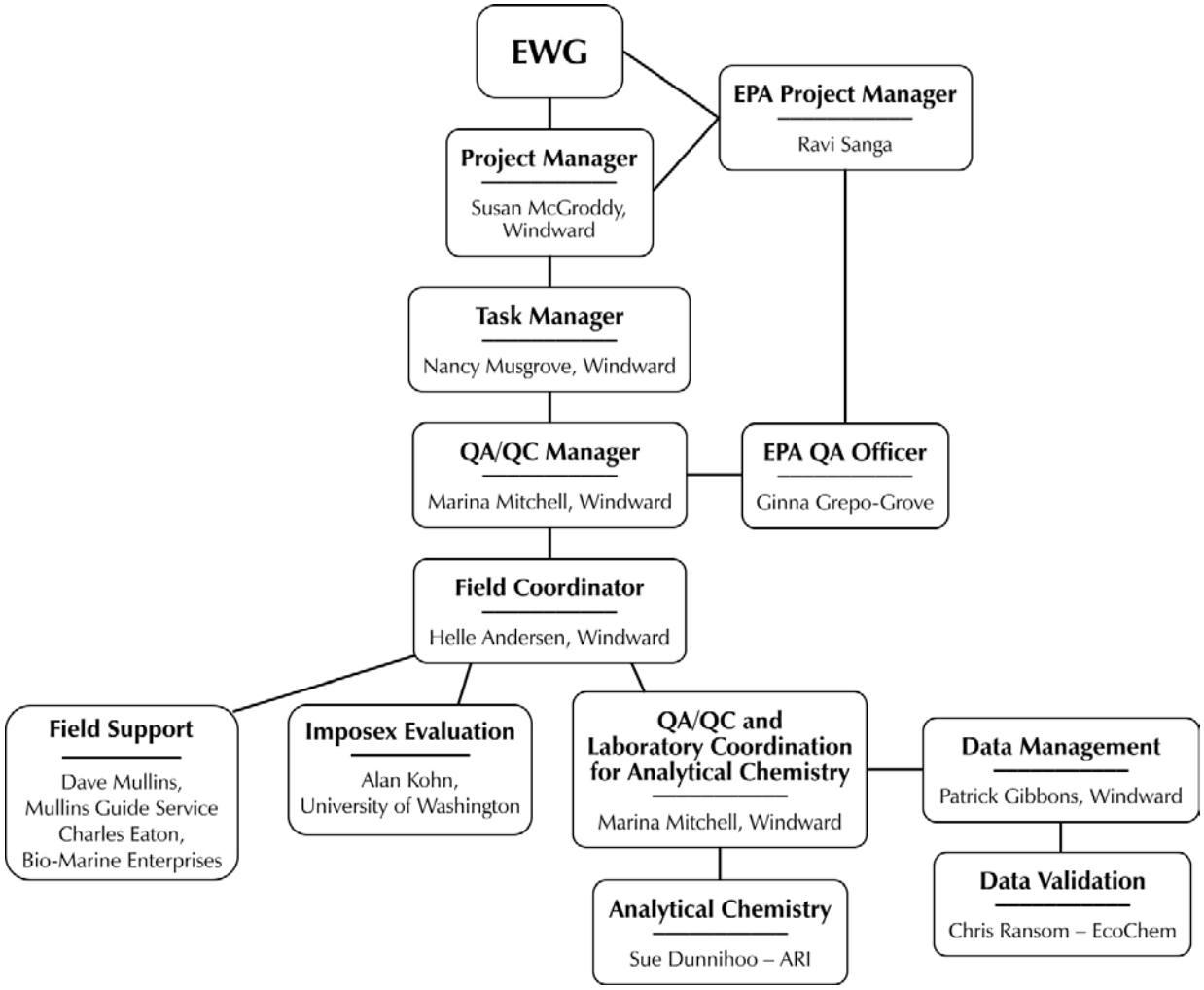

Figure 2-1. Project organization

2.1.1 Project Management

EPA will be represented by its project manager (PM) for this project, Ravi Sanga. Mr. Sanga can be reached as follows:

Mr. Ravi Sanga
US Environmental Protection Agency, Region 10
1200 Sixth Avenue, Suite 900
ECL-111
Seattle, WA 98101-3140
Telephone: 206.553.4092
Facsimile: 206.553.0124
E-mail: Sanga.Ravi@epamail.epa.gov

Susan McGroddy will serve as the Windward PM and will be responsible for overall project coordination and for providing oversight on planning and coordination, work plans, all project deliverables, and performance of the administrative tasks needed to ensure timely and successful completion of the project. She will also be responsible for coordinating with EWG and EPA on schedule, deliverables, and other administrative details. Dr. McGroddy can be reached as follows:

Dr. Susan McGroddy
Windward Environmental LLC
200 W Mercer Street, Suite 401
Seattle, WA 98119
Telephone: 206.812.5421
Facsimile: 206.217.0089
E-mail: susanm@windwardenv.com

Nancy Musgrove will serve as the Windward task manager (TM). The TM is responsible for project planning and coordination, production of work plans, production of project deliverables, and the performance of the administrative tasks needed to ensure timely and successful completion of the project. The TM is responsible for communicating with the Windward PM on the progress of project tasks and any deviations from the QAPP. Significant deviations from the QAPP will be further reported to EWG and EPA. Ms. Musgrove can be reached as follows:

Ms. Nancy Musgrove
Windward Environmental LLC
200 W Mercer Street, Suite 401
Seattle, WA 98119
Telephone: 206.812.5431
Facsimile: 206.217.0089
E-mail: nancym@windwardenv.com

2.1.2 Field coordination

Helle Andersen will be the Windward field coordinator (FC). The FC is responsible for managing the field activities and for general field QA/QC oversight. She will ensure that appropriate protocols for sample collection, preservation, and holding times are observed and oversee the delivery of environmental samples to the designated laboratories for chemical analysis. Ms. Andersen can be reached as follows:

Ms. Helle Andersen
Windward Environmental LLC
200 W Mercer Street, Suite 401
Seattle, WA 98119
Telephone: 206.812.5402
Facsimile: 206.217.0089
E-mail: helleb@windwardenv.com

2.1.3 Quality assurance/quality control

Marina Mitchell of Windward will serve as QA/QC manager for the project. As the QA/QC manager, she will provide oversight for the coordination of the field sampling and laboratory programs and will ensure compliance with the QAPP. She will also supervise data validation and project QA coordination, including coordination with the EPA QA officer, Ginna Grepo-Grove.

Ms. Mitchell can be reached as follows:

Ms. Marina Mitchell
Windward Environmental LLC
200 W Mercer Street, Suite 401
Seattle, WA 98119
Telephone: 206.812.5424
Facsimile: 206.217.0089
E-mail: marinam@windwardenv.com

Ms. Grepo-Grove can be reached as follows:

Ms. Ginna Grepo-Grove
US Environmental Protection Agency, Region 10
1200 Sixth Avenue, Suite 900 (OEA-095)
Seattle, WA 98101
Telephone: 206.553.1632
E-mail: grepo-grove.gina@epa.gov

EcoChem, Inc. will provide independent third-party review and validation of analytical chemistry data. Chris Ransom will act as the data validation PM and can be reached as follows:

Ms. Chris Ransom
EcoChem, Inc.

Dexter Horton Building
710 Second Avenue, Suite 600
Seattle WA 98104
Telephone: 206.233.9332
E-mail: cransom@ecochem.net

2.1.4 Imposex/intersex assessment

Alan Kohn will perform the imposex/intersex analysis of the gastropods. Dr. Kohn can be reached as follows:

Dr. Alan Kohn
Professor Emeritus, Zoology
Box 351800
University of Washington
Seattle, WA 98195
Telephone: 206.616.4383
E-mail: kohn@u.washington.edu

2.1.5 Laboratory project management

Ms. Mitchell of Windward will also serve as the laboratory coordinator for the analytical chemistry laboratory. Analytical Resources, Inc. (ARI) will perform chemical analyses on the tissue and sediment samples. ARI will be responsible for analysis of all analytes. The laboratory PMs can be reached as follows:

Ms. Susan Dunnihoo
Analytical Resources, Inc.
4611 S 134th Place, Suite 100
Tukwila, WA 98168
Telephone: 206.695.6207
E-mail: sue@arilabs.com

The laboratories will do the following:

- Adhere to the methods outlined in this QAPP, including the methods referenced for each procedure
- Adhere to documentation, custody, and sample logbook procedures
- Implement QA/QC procedures defined in this QAPP
- Meet all reporting requirements
- Deliver electronic data files as specified in this QAPP
- Meet turnaround times for deliverables as described in this QAPP
- Allow EPA and the QA/QC third-party auditors to perform laboratory and data audits

2.1.6 Data management

Mr. Patrick Gibbons will oversee data management to ensure that analytical data are incorporated into the EW database with appropriate qualifiers following acceptance of the data validation. QA/QC of the database entries will ensure accuracy for use in the ERA.

2.2 PROBLEM DEFINITION/BACKGROUND

The Duwamish River discharges to Elliott Bay (Map 2-1) in Seattle, Washington. The river forms two branches approximately 1 mile from its mouth. The EW is the eastern branch of the Duwamish River along the east side of Harbor Island. This site has been designated as an operable unit of the Harbor Island Superfund site.

Windward is conducting an ERA as part of the SRI and FS of the EW sediments. The objective of this sampling effort is to further characterize the EW environment and use data gathered from these efforts to assess risks from contaminated sediments posed to the organisms living in the EW. Risk estimates for ecological receptors will be calculated from chemical concentrations in sediment, water, and biota from the EW. Cleanup of sediment contamination will occur in the EW as part of the Superfund process to address identified risks to human and ecological receptors.

The benthic invertebrate tissue and gastropod collection and analysis is designed to address data gaps identified in the draft conceptual site model and data gaps analysis report (Anchor, Windward and Battelle 2008) for the EW. No historical invertebrate tissue chemistry data representing the small benthic organisms that live in or on the sediment of the EW are available, resulting in a need for benthic invertebrate tissue sampling. In addition, benthic invertebrates are potential prey of select ecological receptors of concern (ROCs) that feed within the waterway either seasonally or year-round. Tissue data will be used to evaluate the exposure of benthic invertebrates and fish to selected chemicals. Exposures will be represented by either a critical tissue burden (for benthic invertebrates) or a dietary pathway (fish and wildlife) for selected chemicals consistent with the approach developed for the Lower Duwamish Waterway (LDW) ecological risk assessment assessment.

The primary lines of evidence for evaluating risks to the benthic community will be the comparison of sediment chemistry and toxicity to Washington State Sediment Management Standards (SMS) regulatory thresholds. The exception to this is the evaluation of potential risks associated with exposure to TBT, which does not have a bulk sediment chemical standard. For TBT, a critical tissue-residue approach will be used to assess potential effects on the survival, growth, and reproduction of benthic invertebrates. A tissue-residue approach will also be used as an additional line of evidence for two bioaccumulative compounds (PCBs and mercury). Benthic invertebrate tissue data are needed to provide this chemical-specific assessment.

Gastropods will be collected from the EW under a separate sampling effort (the schedule is still to be determined). Based on the scientific literature, the benthic

invertebrates most sensitive to TBT that may be found in the EW are snails, specifically prosobranch gastropods[1] (Meador et al. 2002). At sufficiently high tissue concentrations, TBT is known to cause the malformation of female sexual organs or development of male sexual organs (conditions known as imposex and intersex) in female gastropods, which, if sufficiently pronounced, can interfere with reproduction and potentially result in population-level effects (Gibbs and Bryan 1996).

The occurrence and prevalence of imposex or intersex will be evaluated in gastropods greater than 2 cm in length[2], if they are found in the EW during this sampling effort. These data will be used as another indication of exposure to TBT; the degree of imposex or intersex will be used to assess the potential effects of TBT on gastropods as a component of the benthic community.

An assessment of dietary exposure to polycyclic aromatic hydrocarbons (PAHs) and non-bioaccumulative metals (i.e., metals other than mercury and selenium) from the consumption of benthic invertebrates is proposed for two of the fish ROCs (juvenile Chinook salmon and English sole). These chemicals tend to be metabolically degraded or regulated by fish such that a critical tissue-reside approach for fish ROCs may not adequately address exposure. Thus, benthic invertebrate tissue-residue data are necessary to support the evaluation of the dietary exposure pathway of these chemicals for two fish ROCs. Consistent with LDW, this evaluation will be conducted using a market basket approach.

Surface (i.e., top 10 cm) sediment will also be collected either during the invertebrate tissue sampling effort .

The data uses for the benthic invertebrate and sediment data are summarized in Table 2-1.

Table 2-1. Data uses for benthic invertebrate and sediment data

MATRIX	ROC	ENDPOINT	ROC EXPOSURE AREA	DATA USE
Benthic invertebrate tissue	benthic invertebrate community	PCBs, mercury, tributyltin concentrations	localized areas	compare individual composite concentrations and the 95th UCL to tissue TRV to evaluate risk to benthic community
	juvenile Chinook salmon	PAHs, metals[a] concentrations	shallow subtidal areas	compare 95th UCL to dietary TRV to evaluate risk to juvenile Chinook
	English sole	PAHs, metals[a] concentrations	site-wide	compare 95th UCL to dietary TRV to evaluate risk to benthivorous fish
Individual gastropods	benthic invertebrate community	incidence and stage of imposex and intersex	localized areas	preponderance of evidence supporting benthic community effects from TBT

[1] Includes snails in the taxonomic orders of Mesogastropoda and Neogastropoda.
[2] Genitalia of smaller specimens cannot be evaluated.

MATRIX	ROC	ENDPOINT	ROC EXPOSURE AREA	DATA USE
Surface sediment	benthic invertebrate community	PCBs, metals, PAHs and other SVOCs	localized areas	compare to SMS chemical criteria to evaluate risks to benthic community

[a] Metals assessed using a dietary approach include antimony, arsenic, cadmium, chromium, cobalt, copper, lead, molybdenum, nickel, silver, thallium, vanadium, and zinc.

PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
ROC – receptor of concern
SMS – Washington State Sediment Management Standards
SVOC – semivolatile organic compound
TRV – toxicity reference value
UCL – upper confidence limit on the mean

2.3 PROJECT/TASK DESCRIPTION AND SCHEDULE

The benthic invertebrate sampling will be initiated following EPA's approval of this QAPP. This section provides an overview of the sampling and analysis activities and schedule for this effort. Detailed sampling designs are presented in Section 3.1.

2.3.1 Benthic invertebrate tissue collection

Benthic invertebrate tissue collection will take place over 7 days, between October 13 and 29, 2008. Fall sampling represents a conservative sampling period from the standpoint of exposure to COIs, due the peak in abundance and biomass that occurs following spring and summer recruitment and growth[3]. Invertebrate tissue samples will be archived until decisions about compositing sampling areas or the prioritization of analyses are made in consultation with and approved by EPA.

2.3.2 Gastropod collection

The current use of EW habitats by prosobranch gastropods is unknown. The presence and abundance of these gastropods will be evaluated during invertebrate collection. The locations where gastropods are present during the tissue collection effort will be noted and the sampling coordinates recorded. Locations with gastropods will be re-occupied and sampled specifically for these organisms. Up to two field days will be dedicated to the collection of gastropods. . The gastropod collection will be conducted as a separate investigation (the schedule is still to be determined).

2.3.3 Sediment sampling

Surface (i.e., top 10 cm) sediment will be sampled for all locations where grab samples are collected for invertebrate tissue. Sediment will be composited to create a sediment composite for each benthic tissue composite sample (Section 3.1).

[3] Historical data from Nichols (1975) and Word et al. (1983) showed maximum annual infaunal total abundance occurring in October. Alden et al. 1997 reports maximum infaunal biomass in fall and winter in the Chesapeake Bay estuary.

2.3.4 Sample analysis, validation, and reporting

Invertebrate tissues and co-located sediments will be analyzed within 4 weeks following consultation with EPA regarding tissue sample compositing strategies. Data will be validated within 5 weeks of receipt of the final data packages from the laboratories. A draft data report presenting the chemical data for all the tissue and co-located sediment samples will be submitted to EPA within 8 weeks of Windward's receipt of validated data. Imposex/intersex data will be presented in a separate data report. Each report will be finalized within 4 weeks of receiving comments from EPA on the draft report.

2.3.5 Summary schedule

The schedule for field work is summarized in Table 2-2.

Table 2-2. Project schedule for benthic invertebrate tissue, gastropod, and sediment collection

ACTIVITY	TENTATIVE START DATE	TENTATIVE END DATE
Invertebrate tissue and co-located sediment sampling	October 14, 2008	October 29, 2008
Gastropod sampling	TBD	Within two days of start date
Consultation with EPA on tissue compositing	October 29, 2008	October 29, 2008
Analysis of benthic invertebrate tissue and co-located sediment	--	4 weeks following EPA approval of compositing strategy
Imposex analysis	TBD	Within two days of start date
Data validation	--	5 weeks from receipt of final laboratory data package
Data report	--	8 weeks from receipt of validated data

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2.4 DATA QUALITY OBJECTIVES AND CRITERIA

The overall data quality objective (DQO) for this project is to develop and implement procedures that will ensure the collection of representative data of known, acceptable, and defensible quality. Parameters used to assess data quality are precision, accuracy, representativeness, comparability, completeness, and sensitivity. These parameters are discussed, and specific data quality indicators (DQIs) for tissue and sediment laboratory analysis are presented, in Section 3.5.2.

2.5 SPECIAL TRAINING/CERTIFICATION

The Superfund Amendments and Reauthorization Act of 1986 requires the Secretary of Labor to issue regulations providing health and safety standards and guidelines for workers engaged in hazardous waste operations. The federal regulation 29CFR1910.120 requires training to provide employees with the knowledge and skills necessary to enable them to perform their jobs safely and with minimum risk to their health. All sampling personnel will have completed the 40-hour hazardous waste operations and emergency response (HAZWOPER) training course and 8-hour refresher courses, as necessary, to meet Occupational Safety and Health Administration regulations.

2.6 DOCUMENTATION AND RECORDS

The following sections describe documentation and records needed for field observations and laboratory analyses.

2.6.1 Field observations

All field activities will be recorded in a field logbook maintained by the FC. The field logbook will provide a description of all sampling activities, conferences associated with field sampling activities, sampling personnel, and weather conditions, plus a record of all modifications to the procedures and plans identified in this QAPP and the HSP (Appendix A). The field logbook will consist of bound, numbered pages. All entries will be made in indelible ink. The field logbook is intended to provide sufficient data and observations to enable participants to reconstruct events that occurred during the sampling period.

The following field data collection sheets (included as Appendix B) will also be used to record pertinent information after sample collection:

- Surface sediment collection form
- Invertebrate (including live gastropod) collection form
- Protocol modification form
- Corrective action form

2.6.2 Laboratory records

The various laboratory record requirements for the co-located tissue and sediment chemistry data are described in this section. The chemistry laboratory will be responsible for internal checks on sample handling and analytical data reporting and will correct errors identified during the QA review. The laboratory data package will be submitted electronically and will include the following:

- **Project narrative**: This summary, in the form of a cover letter, will present any problems encountered during any aspect of analysis. The summary will include, but not be limited to, a discussion of QC, sample shipment, sample

storage, and analytical difficulties. Any problems encountered by the laboratory, and their resolutions, will be documented in the project narrative.

- **Records**: Legible copies of the chain-of-custody (COC) forms will be provided as part of the data package. This documentation will include the time of receipt and the condition of each sample received by the laboratory. Additional internal tracking of sample custody by the laboratory will also be documented.
- **Sample results**: The data package will summarize the results for each sample analyzed. The summary will include the following information, as applicable:
  - Field sample identification code and the corresponding laboratory identification code
  - Sample matrix
  - Date of sample extraction/digestion
  - Date and time of analysis
  - Weight and/or volume used for analysis
  - Final dilution volumes or concentration factor for the sample
  - Percent moisture in the samples
  - Identification of the instruments used for analysis
  - Method detection limits (MDLs) and reporting limits (RLs)
  - All data qualifiers and their definitions
- **QA/QC summaries:** These summaries will contain the results of all QA/QC procedures. Each QA/QC sample analysis will be documented with the same information as that required for the sample results (see above). The laboratory will make no recovery or blank corrections. The required summaries are listed below.
  - The calibration data summary will contain the concentrations of the initial calibration and daily calibration standards and the date and time of analysis. The response factor, percent relative standard deviation (%RSD), relative percent differences (RPDs), and retention time for each analyte will be listed, as appropriate. Results for standards analyzed at the RL to determine instrument sensitivity will be reported.
  - The internal standard area summary will report the internal standard areas, as appropriate.
  - The method blank analysis summary will report the method blank analysis associated with each sample and the concentrations of all compounds of interest identified in these blanks.

- The surrogate spike recovery summary will report all surrogate spike recovery data for organic analyses. The names and concentrations of all compounds added, percent recoveries, and QC limits will be listed.
- The matrix spike (MS) recovery summary will report the MS or MS duplicate (MSD) recovery data for analyses, as appropriate. The names and concentrations of all compounds added, percent recoveries, and QC limits will be included in the data package. The RPD for all MS/MSD analyses will be reported.
- The laboratory replicate summary will report the RPD for all laboratory replicate analyses. The QC limits for each compound or analyte will be listed.
- The standard reference material (SRM) analysis summary will report the results and recoveries of the SRM analyses and list the accuracy, as defined in Section 3.5.2, for each analyte, when available.
- The laboratory control sample (LCS) analysis summary will report the results of the analyses of the LCS. The QC limits for each compound or analyte will be included in the data package.
- The relative retention time summary will report the relative retention times for the primary and confirmational columns of each analyte detected in the samples, as appropriate.

- **Original data:** Legible copies of the original data generated by the laboratory will be provided, including the following:
  - Sample preparation, extraction/digestion, and cleanup logs
  - Instrument analysis logs for all instruments used on days of calibration and analysis
  - Chromatograms for all samples, blanks, calibration standards, MS/MSD, laboratory replicate samples, LCS, and SRM samples for all gas chromatography analyses
  - Reconstructed ion chromatograms of target chemicals detected in the field samples and method blanks for all gas chromatography/mass spectrometry (GC/MS) analyses
  - Enhanced and unenhanced spectra of target chemicals detected in field samples and method blanks, with associated best-match spectra and background-subtracted spectra, for all GC/MS analyses
  - Quantitation reports for each instrument used, including reports for all samples, blanks, calibrations, MS/MSD, laboratory replicates, LCS, and SRMs

The contract laboratory for this project will submit data electronically, in EarthSoft EQuIS® standard four-file format. Guidelines for electronic data deliverables for chemical data is provided on the EarthSoft website, http://www.earthsoft.com/en/index.html, and additional information will be communicated to the laboratory by the project QA/QC coordinator or data manager. All electronic data submittals must be tab-delimited text files with all results, MDLs, and RLs reported to the appropriate number of significant figures. If laboratory replicate analyses are conducted on a single submitted field sample, the laboratory sample identifier must distinguish among the replicate analyses.

2.6.3 Data reduction

Data reduction is the process by which original data (analytical measurements) are converted or reduced to a specified format or unit to facilitate data analysis. Data reduction requires that all aspects of sample preparation that could affect the test result, such as sample volume analyzed or dilutions required, be taken into account in the final result. It is the laboratory analyst's responsibility to reduce the data, which are subjected to further review by the laboratory data review specialists, laboratory PM, project QA/QC coordinator, project PM, and independent data reviewers. The data will be generated in a form amenable to review and evaluation. Data reduction may be performed manually or electronically. If performed electronically, all software used must be demonstrated to be true and free from unacceptable error.

2.6.4 Data report

A data report will be prepared to document all activities associated with the collection, handling, and analysis of samples. At a minimum, the following will be included in the data report:

- Summary of all field activities, including descriptions of any deviations from the approved QAPP
- Summary spreadsheet containing information from field forms
- Extent of the sediment and benthic invertebrate sampling areas reported in latitude and longitude to the nearest one-tenth of a second and in northing and easting to the nearest foot
- Plan view of the project showing the actual sampling locations
- Summary of the QA/QC review of the analytical data including a comparison of RLs with ACGs
- Results from the analysis of field samples included as summary tables in the main body of the report, data forms submitted by the laboratories, and cross-tab tables produced from Windward's database
- Results of the gastropod imposex study presented either as an attachment to the data report or under separate cover (depending on timing of collection and

analysis), including an enumeration of neo- and mesogastropods to genus or species and the results of the imposex analysis

Summary statistics (i.e., mean, minimum, maximum, and frequency of detection) will be provided to characterize the chemistry results. Once the data report has been approved by EPA, a database export will be created from Windward's database. The data will be exported in a format compatible with Ecology's Environmental Information Management System, which requires separate tables for events, locations, samples, and results. Data will also be provided to EPA in Microsoft Access®. Any relevant geographic information system files will also be transmitted to EPA.

3 Data Generation and Acquisition

This section describes the collection and processing of benthic invertebrate tissue samples and sediment samples for chemical analysis and the collection and documentation of the occurrence of imposex in neo- and mesogastropods found in the EW. Elements include sampling design, sampling methods, sample-handling and custody requirements, analytical methods, QA/QC, instrument and equipment testing and frequency, inspection and maintenance, instrument calibration, supply inspection and acceptance, non-direct measurements, and data management. The studies detailed in this QAPP are described in the following subsections.

3.1 SAMPLING DESIGN

The field sampling effort will collect information about the benthic invertebrate community in the EW to support the ERA. Benthic invertebrates will be collected from subtidal areas of the EW that may provide habitat for benthic organisms or foraging areas for fish and wildlife that prey on benthic organisms. Co-located sediment will be collected during the invertebrate sampling effort to characterize benthic invertebrate exposure to COIs in whole sediment. Sample collection and compositing techniques will depend on the abundance and biomass of benthic organisms found in the sampling areas. Prosobranch gastropods will be collected from the same invertebrate sampling areas where they were found in the benthic samples.

The EW will be divided into 13 sampling areas (Map 3-1) that reflect the physical configuration of the waterway and ROC use. The main waterway, which is composed primarily of deep subtidal habitats, is divided into eight segments (Areas 3 through 6 and 8 through 11). Segment boundaries were selected to reflect major shifts in sediment grain size characteristics and dredging history (Map 3-1). Areas 3 and 4 have predominately fine-grained sediment and have not been dredged in recent history. Areas 5, 6, 8, and 9 encompass the main portion of the waterway that has been recently dredged. The sediment in Areas 10 and 11 is primarily coarse-grained and only the western half of Area 11 has been dredged recently. Shallow areas (i.e., less than -20 ft mean lower low water), which represent the preferred foraging habitat of

juvenile Chinook[4][5] salmon, will make up the other five sampling areas (Areas 1, 2E, 2W, 7 and 12). These shallow sampling areas are small. Area 1 represents the segment south of the Spokane Street Bridge; Areas 2E and 2W encompass either side of the narrow head of the waterway just north of the Spokane Street Bridge to southern boundary of Terminals 18 and 25; Slip 27 forms Area 7; and Slip 36 is Area 12. Boat access immediately under the railroad and Spokane Street bridges is restricted and will not be sampled. Sampling will only occur in Slip 36 upon permission being granted by the US Coast Guard.

Benthic invertebrates can be collected in subtidal environments using several different types of equipment, including grab samplers, box corers, or a benthic sledge. A benthic sledge can sample a larger area of the bottom while grab and box core samples provide more area-specific samples. Few invertebrates (and little biomass) were encountered while using a 0.1-m^2 van Veen grab sampler during a reconnaissance survey conducted by Windward on February 1, 2008. Use of a benthic sledge was proposed for invertebrate tissue sampling; however, based on concerns expressed by EPA and its partners regarding the scale of sampling and correlation with surface sediment samples, a double 0.1 m^2 van Veen grab will be initially used in the attempt to obtain sufficient biomass. Ten grabs will be deployed across each sampling area; sampling will focus on nearshore areas or areas with historically elevated sediment chemistry. Organisms from these grabs will be sorted, weighed, and composited. Sediment from each grab sample that contributed benthic tissue to the benthic tissue composte will be combined in equal volumes to create a sediment composite sample for each sampling area. If insufficient tissue is collected after approximately 10 grabs, collection of additional grabs or use of the benthic sledge will be discussed with EPA oversight personnel; alternative sampling approaches will be implemented upon approval. A benthic sledge will also be used for the gastropod collection.

3.1.1 Analyte list

Chemicals of interest (COIs) identified for benthic tissue for the assessment of dietary risk to fish (PAHs and metals [other than mercury and selenium]) and the tissue residue-based assessment of benthic invertebrate tissue (PCBs, TBT and mercury) are presented in Table 3-1. Sediment analytes for composited sediment will reflect those analyzed in tissue.

Table 3-1. Chemicals of Interestfor Infaunal tissue and Sediment

METALS	PAHS
Antimony	Acenaphthene
Arsenic	Acenaphthylene
Cadmium	Anthracene

[4] Juvenile Chinook salmon in the LDW and Elliott Bay have been reported to be relatively more abundant in beach seine samples than in deeper purse seine samples, indicating that they use shallow shoreline habitats more than the deep water habitat (Weitkamp and Schadt 1982).

[5] Data collected from shallow areas will be used for all applicable ROCs.

Chromium	Benzo(a)anthracene
Cobalt	Benzo(a)pyrene
Copper	Benzo(b)fluoranthene
Lead	Benzo(g,h,i)perylene
Mercury	Benzo(k)fluoranthene
Molybdenum	Chrysene
Nickel	Dibenzo(a,h)anthracene
Silver	Fluoranthene
Thallium	Fluorene
Vanadium	Indeno(1,2,3-cd)pyrene
Zinc	Naphthalene
	Phenanthrene
BUTYLTINS	Pyrene
Dibutyltin as ion	
Tributyltin as ion	
PCBS	
TOTAL PCBS (AROCLORS)	

COI – chemical of interest
PAH – polycyclic aromatic hydrocarbon
PCBs–polychlorinated biphenyls

The analytical tissue methods and mass requirements for the COIs are discussed in Section 3.5. If insufficient tissue mass is collected in one or more sampling areas, EWG will consult with EPA to identify the appropriate analytical strategy. Method modifications may include modified extraction techniques (e.g., adjusting the final extract volume), using a lower concentration for the lowest standard in the initial calibration, or adjusting the amount of extract injected into the instrument.

3.2 SAMPLING METHODS

The sampling methods for the collection of benthic invertebrates are described in separate subsections below. During field activities, there may be contingencies that require modification of the general procedures outlined below. Modifications will be at the discretion of the FC after consultation with the Windward PM and the boat operator, if applicable. EPA will be consulted in the event that significant deviations from the sampling design are required. All modifications will be recorded in the logbook.

3.2.1 Identification scheme for all locations and samples

Each sampling area will be assigned a unique alpha-numeric location identification (ID) number. The first two characters of the location ID are "EW" to identify the East Waterway project area. The next two characters will be "08" to indicate that the sample was collected in 2008, followed by a five-character survey sampling area

designation. The first four characters will indicate the sampling segment (BI01 thorough BI12); the fifth character will be used to indicate subarea (E[ast] or W[est]), where applicable. The next characters will identify the sample matrix (sediment grab [S] and sequential number, benthic tissue [T], or clam tissue [C]. Once sediment samples from an area are composited in the lab, a unique sample number will be assigned to the composite sample. Composite samples will be identified using a similar convention, with the following differences. The grab sequence number will be followed by "-Comp". Field/lab notes will indicate which samples contributed to that composite.

Examples of naming conventions for the invertebrate tissue samples follow:

- EW08-BI02W-T (East Waterway, 2008 benthic invertebrate tissue survey, sampling area 2W, multi-species invertebrate tissue.)
- EW08-BI02W-C (East Waterway, 2008 benthic invertebrate tissue survey, sampling area 2, western subarea, clam (>2cm) tissue.)
- EW08-BI07-S3 (East Waterway, 2008 benthic invertebrate tissue survey, 3rd sediment grab from sampling area 7.)
- EW08-BI07-S -Comp (East Waterway, 2008 benthic invertebrate tissue survey, sediment composite from sampling area 7.)

3.2.2 Location positioning

Sampling locations will be documented using a differential global positioning system (DGPS). A DGPS unit mounted on the winch arm will be used with equipment deployed from a sampling vessel (e.g., benthic sledge). Individual grab sampling coordinates will be recorded at each point; start and end coordinates will be collected for each benthic sledge tow path. The DGPS unit is wide-area augmentation system enabled and will receive DGPS signals from satellites to both triangulate a position and provide a locational correction factor, resulting in positioning accuracy of within 3 m. Washington State Plane Coordinates North (NAD 83) will be used for the horizontal datum.

3.2.3 Collection Methods

This section presents the sample collection, handling, and compositing procedures. A contingency plan for cases in which too little invertebrate tissue is collected is also proposed.

A double 0.1 m^2 van Veen grab sampler will be used to collect benthic invertebrates and co-located surface sediments. Grab sampling for co-located sediment will be conducted according to standard operating procedures (PSEP 1997). The PSEP protocols will generally be followed for invertebrate tissue collection; however, criteria that minimize sediment disturbance are not applicable to tissue collection.

The steps for use of a van Veen grab sampler are as follows:

1. Using DGPS, maneuver the sampling vessel to the approximate pre-identified sampling location.
2. Open the grab sampler jaws into the deployment position.
3. Guide the sampler overboard until it is clear of the vessel.
4. Using DGPS, position the sampling vessel such that the GPS receiver, mounted on the winch arm right over the grab sampler, is within 1 to 2 m of the intended sampling location.
5. Lower the sampler through the water column to the bottom at approximately 0.3 m/s.
6. Record the DGPS location of the boat when the sampler reaches the bottom.
7. Record the water depth and time.
8. Retrieve the sampler, and raise it at approximately 0.3 m/s.
9. Guide the sampler aboard the vessel, and place it on the work stand on the deck, using care to avoid jostling that might disturb the integrity of the sample.
10. Examine the sample using the following sediment acceptance criteria:
    - Sediment is not extruded from the upper face of the sampler.
    - Overlying water is present (indicating minimal leakage).
    - Sediment surface is relatively flat (indicating minimal disturbance or winnowing).
    - A penetration depth of at least 11 cm is achieved.

If these sample acceptance criteria are not achieved for those sediment samples intended for chemical analysis, the sample will be rejected (samples for tissue collection will be retained, regardless of sample condition). After sample collection, the following observations will be noted in the field logbook:

- DGPS location
- Depth, as read by the boat's depth sounder
- Gross characteristics of the surface sediment, including texture, color, biological structures, odor, and presence of debris or oily sheen
- Gross characteristics of the vertical profile (i.e., changes in sediment characteristics and redox layer, if visible)
- Maximum penetration depth (nearest 0.5 cm)
- Comments relative to sample quality

Each grab for tissue collection will be screened through a 1.0-mm mesh sieve, and all organisms will be retained for analysis. Those organisms <2cm will be included in the benthic tissue composite. Clams such as *Macoma* spp. that are larger than 2 cm will be

separated and archived separately, until decisions can be made about potential analyses, following discussion with EPA.

Ten or more grabs will be deployed in each sampling area. Tissue will be composited in the field and a equal volume of sediment[6] from each grab which contained tissue will becombined to create a sediment composite for each tissue composite sample.

A benthic sledge (Figure 3-1) will be used to collect benthic invertebrates in sampling areas where the grab sampler is unsuccessful in collecting sufficient tissue and for gastropods. The benthic sledge is pulled behind a boat and collects benthic invertebrates by "skimming" the top (i.e., 2 cm to approximately 7 cm) layer of the sediments. The sledge consists of a 1-mm mesh bag protected by a heavy canvas cloth that is suspended from a rectangular metal frame. The sledge is towed along the bottom by a rope that attaches to the edges of the frame. The shape of the frame and the angle and length of rope are used to maintain the sledge's orientation along the bottom and the depth at which it digs into the sediment.

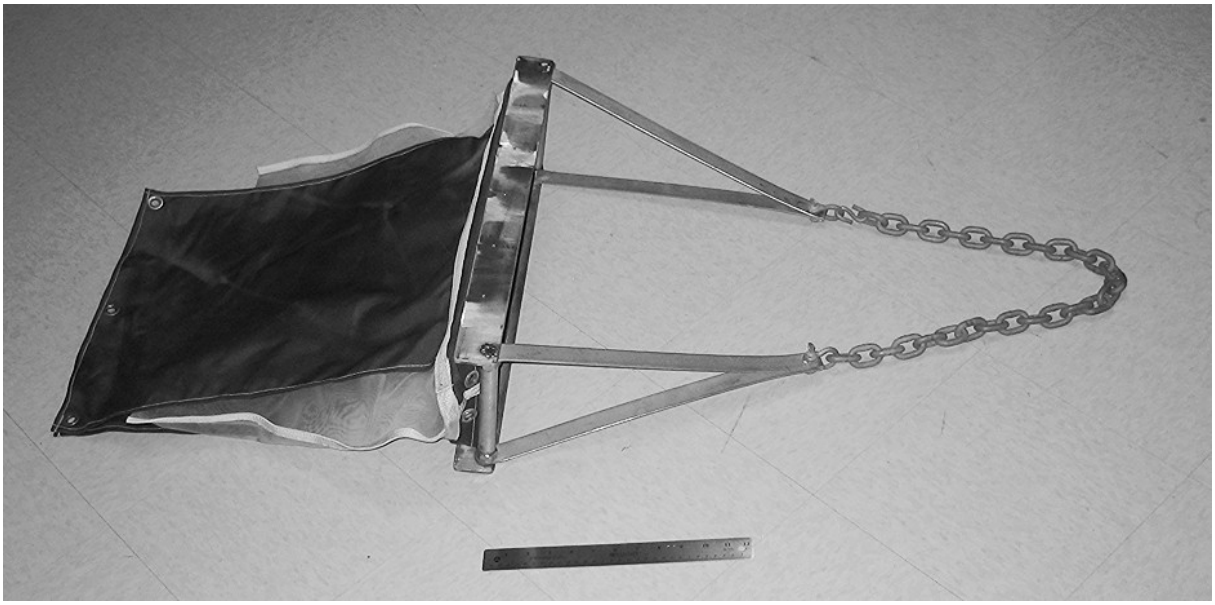

Figure 3-1. Benthic sledge sampler

The benthic sledge will be towed a maximum of five times through each of the accessible sampling areas for invertebrate tissue or gastropod collection. Each tow path will align with depth contours and extend the length of the sampling area, where possible. An attempt will be made to collect tissue or snails from each sampling area; however, field conditions, including vessel traffic, will govern actual tow path alignments and lengths. A DGPS will be used to identify the start and end of each sledge deployment. To the extent possible, the sledge will be towed at the same speed

[6] An aliquot of sediment will be collected first and then the remainder will be processed for tissue collection.

and for the same amount of time in sampling areas of similar size. The sledge will be retrieved at the end of each tow, and the contents of the bag will be rinsed into a 1.0-mm mesh sieve. All organisms less than 2 cm (in length/width) in the initial tows will be retained for analysis; however, only gastropods will be kept from the tows targeting snails. Gastropods will be placed in a glass jar with site water and held on ice for an evaluation of imposex and intersex using live organisms. *Macoma* spp. or other clams larger than 2 cm will be sorted and retained for potential analyses, following discussions with EPA. Analytical strategies and prioritization will be discussed with EPA where insufficient tissue mass is collected in one or more sampling areas.

3.2.4 Field equipment

The items listed in Table 3-2 will be needed in the field.

Table 3-2. Field equipment

Benthic sledge	Coolers	Field notebooks
Double 0.1-m^2 van Veen grab sampler	Wet ice	Pens/pencils/Sharpies®
1.0-mm mesh sieves	Aluminum foil	Tide tables
Weights for samplers	Digital camera	Personal flotation device
Spray bottle/garden sprayer	Batteries	QAPP
Stainless steel bowls and spoons	Powder-free nitrile exam gloves	Sample labels
Alconox® detergent	Rubber work gloves	Field collection forms
Scrub brushes	First aid kit	Study area maps
Distilled water	Duct tape	Chain-of-custody forms
Paper towels	Boots/raingear	Collection permit
Glass jars	Zip-lock bags	Plastic garbage bag
Forceps	Scale	Sorting trays and table

QAPP – quality assurance project plan

Prior to mobilization, this list will be consulted to ensure that all equipment is available and pre-cleaned. As part of the mobilization process, each item will be double-checked by the FC.

3.3 TAXONOMIC IDENTIFICATION METHODS

If prosobranch gastropods are found in any of the invertebrate tissue tows or grabs, those areas will be resampled for gastropod collection. Individual gastropods will be evaluated for imposex and intersex by Dr. Alan Kohn of the University of Washington. Following collection, gastropods will be identified to order, and if possible to genus or species, at the Windward laboratory using common taxonomic keys. A reference collection will be created by Windward and will be verified by Dr. Kohn. If any discrepancies are identified, a resolution will be reached between Dr. Kohn and Windward on the proper identification(s), and any inconsistency will be corrected throughout the data set.

Samples will be weighed in the shell (wet weight to nearest 0.1 g), and the height of the shell will be measured. After the gastropods have been identified and measured, they will be returned to the sampling jars and stored at Windward in a refrigerator (in site water with mesh covering the jars) until delivery to Dr. Kohn.

3.3.1 Imposex/Intersex Analysis

Dr. Kohn will assess individual prosobranch gastropods that show signs of imposex or intersex. First, the shells will be carefully cracked with a small hammer so as not to kill the gastropod, and the gender of each gastropod will be determined (malformation of sexual organs can most easily be determined on live gastropods). Males will be held on ice for potential reference.

The females will be examined for imposex using the vas deferens sequence index (Spence et al. 1990). This index consists of six stages that describe the development of the vas deferens from its initial appearance and growth (Stages 1 through 4) to the overgrowth of the genital papilla occluding the vulva (Stage 5), resulting in a buildup of egg capsules (Stage 6). Stages 5 and 6 render the female effectively sterile.

If the vas deferens cannot be seen, the level of imposex will be assessed by measuring the penis length of both males and females and using the relative penis size (RPS) approach (Gibbs et al. 1988). The RPS index will be calculated using the following equation:

$$\text{RPS index} = \frac{\text{mean length of female penis}^3}{\text{mean length of male penis}^3} \times 100 \qquad \textbf{Equation 1}$$

Spence et al. (1990) states that, in general, sterile females are absent at RPS indices below 5%. The percentage of sterility increases when the RPS index is between 5% and 40%, and at RPS indices exceeding 40%, most or all females are sterile. The imposex evaluation of each gastropod will be noted on the Gastropod Imposex/Intersex Laboratory Form (see Appendix F). After examination, female gastropods will be placed in separate vials and stored on ice for further reference until completion of the imposex analysis.

Intersex will be evaluated by examining the status of the genital tract. Four stages of malformation can occur in females chronically exposed to TBT (Bauer et al 1995). In Stage 1, the genital opening is enlarged and the initial sperm storage organ (copulatory bursa) is split. In Stage 2, the pallial oviduct is split. In later stages (3 and 4), male sex organs (prostate gland, and later a penis and seminal groove) form, supplanting female organs. Sterility can occur at Stage 2 due to eggs and egg capsule material leaking into the mantle cavity or at Stages 3 and 4, where the glands that form the egg capsules are missing.

When the evaluation is complete, all gastropods will be euthanized (frozen) and discarded.

3.4 SAMPLE HANDLING AND CUSTODY REQUIREMENTS

This section describes how individual samples will be processed, labeled, tracked, stored, and transported to the laboratory for analysis. In addition, this section describes decontamination procedures, procedures for the disposal of field-generated wastes, sample custody procedures, and shipping requirements. Sample custody is a critical aspect of environmental investigations. Sample possession and handling must be traceable from the time of sample collection, through laboratory and data analyses, to delivery of the sample results to the recipient.

3.4.1 Sample handling procedures

Invertebrate tissue and sediment for chemical analysis will be placed in several large pre-cleaned, wide-mouth glass jars and capped with Teflon®-lined lids for transport to the laboratory (Tables 3-3 and 3-4). A minimum of 2.5 cm of head space will be left at the top of all sediment and benthic invertebrate tissue sample containers to prevent breakage during shipping and storage. Live gastropods will also be placed in glass jars, but will be covered with site water and held on ice to maintain adequate oxygen levels. Prior to transfer to the laboratory, each glass container will be wrapped in bubble wrap, individually placed in a zip-lock bag, and placed in a sturdy cooler with frozen gel packs or ice. Each jar or bag containing a sample for chemical analysis will be sealed, labeled, and stored under appropriate conditions, as outlined in Section 3.3.1. Live snails will be refrigerated in open containers at Windward's field laboratory for processing until transfer to Dr. Kohn.

Large clams (>2 cm shell diameter), if encountered, will be sorted in the field and wrapped in clean aluminum foil, shiny side out. Each foil package will be bagged in sealed zip-lock bags and stored on ice (or frozen gel packs) while in the field.

Sediment and invertebrate tissue will be archived, until a compositing strategy is approved by EPA. Tissue and sediment samples will be composited and homogenized at ARI according to their standard operating procedures, following agreement between EPA and EWG regarding a compositing strategy. Once the tissue samples have been composited and homogenized, the homogenate will be stored in appropriately-sized, pre-cleaned, wide-mouth glass jars and capped with Teflon®-lined lids (Table 3-3). The size of the jars will be determined by the discretion of the laboratory. All samples will be stored frozen at the laboratories, with the exception of sediment sample for grain size analysis, which will be refrigerated.

Table 3-3. Container requirements for sediment samples

PARAMETER	CONTAINER TYPE
PCBs (as Aroclors), SVOCs (including PAHs)	16-oz glass jar[a]
Total metals including mercury, butyltins, TOC, total solids	16-oz glass jar[a]
Grain size	16-oz HDPE jar[b]

[a] One sample must be collected in duplicate for laboratory QA/QC samples.

HDPE – high-density polyethylene
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
QA/QC – quality assurance/quality control
SVOC – semivolatile organic compound
TOC – total organic carbon

Sample labels will be waterproof and self-adhering. Each sample label will include the project number, sample identification, preservation technique, analyses, date and time of collection, and initials of the individual(s) preparing the sample. A completed sample label will be affixed to each sample container. The labels will be covered with clear tape immediately after they have been completed to protect them from being stained or soiled from water and sediment. At each laboratory, a unique sample ID will be assigned to each sample.

3.4.2 Decontamination procedures

All sediment and tissue sampling and homogenizing equipment, including the mixing bowl and stainless steel implements, will be decontaminated according to PSEP guidelines (1997a) between stations or samples according to the following procedures:

1. Rinse with site water and wash with a scrub brush until free of sediment.
2. Wash with phosphate-free detergent.
3. Rinse with site water.
4. Rinse with distilled water.

Only step 1 will be used in decontaminating the benthic sledge.

Acid or solvent washes will not be used in the field because of safety considerations and problems associated with rinsate disposal and sample integrity. Specifically:

- The use of acids or organic solvents may pose a safety hazard to the field crew.
- Disposal and spillage of acids and solvents during field activities pose an environmental concern.
- Residues of solvents and acids on sampling equipment may affect sample integrity for chemical testing.

Any sampling equipment that cannot be cleaned to the satisfaction of the FC will not be used for further sampling activity.

3.4.3 Field-generated waste disposal

Excess sediment, generated equipment rinsates, and decontamination water will be returned to each sampling location after sampling has been completed at that location. All disposable sampling materials and personal protective equipment used in sample processing, such as disposable coveralls, gloves, and paper towels, will be placed in heavy-weight garbage bags or other appropriate containers. Disposable supplies will

be removed from the site by sampling personnel and placed in a normal refuse container for disposal as solid waste.

3.4.4 Sample custody procedures

Samples are considered to be in custody if they are: 1) in the custodian's possession or view, 2) retained in a secured place (under lock) with restricted access, or 3) placed in a container and secured with an official seal(s) such that the sample cannot be reached without breaking the seal(s). Custody procedures will be used for all samples throughout the collection, transport, and analytical process. Custody procedures will be initiated during sediment and tissue sample collection. A COC form will accompany samples to the analytical laboratory. Each person who has custody of the samples will sign the COC form and ensure that the samples are not left unattended unless properly secured. Minimum documentation of sample handling and custody will include:

- Project name and unique sample ID
- Sample collection date and time
- Any special notations on sample characteristics or problems
- Initials of the individual collecting the sample
- Date sample was sent to the laboratory
- Shipping company name and waybill number

The FC will be responsible for all sample tracking and custody procedures in the field. The FC will be responsible for final sample inventory and will maintain sample custody documentation. The FC will also complete COC forms prior to removing samples from the sampling area. At the end of each day, and prior to sample transfer, COC entries will be made for all samples. Information on the labels will be checked against sample log entries, and sample tracking forms and samples will be recounted. COC forms will accompany all samples. The COC forms will be signed at each point of transfer. Copies of all COC forms will be retained and included as appendices to the data reports. Tissue and sediment samples will be shipped or hand delivered to the analytical laboratories in sealed coolers with custody seals (gastropod samples will be hand-delivered).

The laboratories will ensure that COC forms are properly signed upon receipt of the samples and will note questions or observations concerning sample integrity on the COC or other sample receipt forms. The laboratories will contact the FC or project QA/QC coordinator immediately if discrepancies between the COC forms and the sample shipment are discovered upon receipt.

The laboratory will ensure that a sample tracking record follows each sample through all stages of laboratory processing. The sample tracking record for chemistry samples must contain, at a minimum, the name or initials of individuals responsible for

performing the analyses, dates of sample extraction or preparation and analyses, and the types of analyses being performed.

3.4.5 Shipping requirements

Sample coolers containing benthic invertebrate tissue and sediment samples will be transported directly to ARI. The temperature inside the cooler(s) containing chemistry samples will be checked by the laboratory upon receipt of the samples. The laboratory will specifically note any coolers that do not contain ice packs or that are not sufficiently cold (4° ± 2°C) upon receipt. Each sample will be assigned a unique laboratory number, and samples will be grouped in appropriate sample delivery groups (SDGs).

Samples will be assigned a specific storage area within the laboratory and will be kept there until analyzed. Tissues will be frozen upon receipt until analysis. The analytical laboratory will not dispose of the environmental samples for this project until notified in writing by the project QA/QC coordinator.

Live gastropods will be hand-delivered to Dr. Kohn's lab, following chain-of-custody procedures.

3.5 ANALYTICAL METHODS

This section discusses laboratory methods, sample-handling requirements, and DQIs for the chemical analyses of the tissue and co-located sediment samples. All tissue and sediment samples will be analyzed for PCB Aroclors, total metals including mercury, butyltins, total solids, lipids (tissue samples only), and PAHs. Sediments will also be analyzed total organic carbon (TOC). If insufficient sample mass is available for all tests, analyses will be prioritized in consultation with EPA, and ways to reduce tissue mass requirements will be investigated.

3.5.1 Laboratory methods and sample handling

Chemical analyses of the tissue and sediment samples will be conducted at ARI as identified in Table 3-5.

Table 3-5. Chemical analyses

PCB Aroclors
PAHs
Total metals, including mercury
Butyltins
Lipids
Total solids
Grain size
Total organic carbon

PAHs –polycyclic aromatic hydrocarbons

Invertebrate tissue will be collected and stored in the field and then shipped to ARI for archiving via freezing. All tissue samples will be homogenized at ARI according to their laboratory standard operating procedures following an agreement between EWG and EPA as to how benthic invertebrate tissues should be composited.

If sufficient tissue is available, benthic invertebrate tissue samples will be analyzed for PAHs, total metals,[7] total mercury, PCBs as Aroclors, butyltins, lipids, and percent solids.

The co-located sediment samples collected at the benthic invertebrate sampling locations will be analyzed for total organic carbon (TOC), total solids, grain size,PAHs, total metals including mercury, PCBs as Aroclors, and butyltins. Analytical methods and sample-handling requirements for tissue and sediment samples are presented in Tables 3-6 and 3-7, respectively.

Table 3-6. Laboratory analytical methods and sample-handling requirements for tissue samples

PARAMETER	METHOD	REFERENCE	SAMPLE HOLDING TIME[a]	PRESERVATIVE
PCBs as Aroclors	GC/ECD	EPA 8082[b]	1 year to extract, 40 days to analyze	freeze/-20°C
PAHs [b]	GC/MS	EPA 8270D[c]	1 year to extract, 40 days to analyze	freeze/-20°C
Tributyltin, dibutyltin, monobutyltin (as ions)	GC/FPD	Krone et al. (1989)	1 year to extract, 40 days to analyze	freeze/-20°C
Total mercury	CVAA	EPA 7471A	6 months	freeze/-20°C
Total metals[c]	ICP-MS, ICP-AES, or GFAAS	EPA 6020, EPA 6010B, or EPA 7000	6 months	freeze/-20°C
Lipids	DCM: acetone gravimetric extraction	NOAA (1993)	1 year	freeze/-20°C
Total solids	freeze-dried or oven-dried	PSEP (1986) or EPA 160.2	6 months	freeze/-20°C

[a] All samples will be archived frozen at the laboratory until the Windward PM or QA/QC officer authorizes their disposal.

[b] Target PAHs include: anthracene, pyrene, dibenzofuran, benzo(g,h,i)perylene, indeno(1,2,3-cd)pyrene, benzo(b)fluoranthene, fluoranthene, benzo(k)fluoranthene, acenaphthylene, chrysene, benzo(a)pyrene, dibenz(a,h)anthracene, benzo(a)anthracene, acenaphthene, phenanthrene, fluorene, 1-methylnaphthalene, naphthalene, and 2-methylnaphthalene.

[c] Antimony, arsenic, cadmium, chromium, cobalt, copper, lead, molybdenum, nickel, silver, thallium, vanadium, and zinc.

CVAA – cold vapor atomic absorption

DCM – dichloromethane

EPA – US Environmental Protection Agency

GC/ECD – gas chromatography/electron capture detection

GC/FPD – gas chromatography/flame photometric detection

[7] Antimony, arsenic, cadmium, chromium, cobalt, copper, lead, molybdenum, nickel, silver, thallium, vanadium, and zinc.

GC/MS – gas chromatography/mass spectrometry
GFAAS – graphite furnace atomic absorption spectrophotometry
ICP-AES – inductively coupled plasma-atomic emission spectrometry
ICP-MS – inductively coupled plasma-mass spectrometry
NOAA – National Oceanic and Atmospheric Administration
PAH – polycyclic aromatic hydrocarbon
PCB –polychlorinated biphenyl
PSEP – Puget Sound Estuary Program

Table 3-7. Laboratory analytical methods and sample-handling requirements for sediment samples

PARAMETER	METHOD	REFERENCE	SAMPLE HOLDING TIME[a]	PRESERVATIVE
PCBs as Aroclors	GC/ECD	EPA 8082	14 days to extract, 40 days to analyze[b]	cool/4°C
PAHs[c]	GC/MS	EPA 8270D	14 days to extract, 40 days to analyze[b]	cool/4°C
Tributyltin, dibutyltin, monobutyltin (as ions)	GC/FPD	Krone et al. (1989)	14 days to extract, 40 days to analyze[b]	cool/4°C
Total mercury	CVAA	EPA 7471A	28 days[e]	cool/4°C
Total metals[d]	ICP-MS, ICP-AES, or GFAAS	EPA 6020, EPA 6010B, or EPA 7000	1 year	cool/4°C
Grain size	sieve/pipette	PSEP (1986)	none	none
TOC	combustion	Plumb (1981)	28 days[e]	cool/4°C
Total solids	oven-dried	PSEP (1986)	7 days[e]	cool/4°C

[a] All samples will be archived frozen at the laboratory until the Windward PM or QA/QC officer authorizes their disposal.

[b] Sediment can also be frozen to increase the holding time to 1 year for extraction. Aqueous rinsate blanks have a maximum holding time of 7 days to extract and 40 days to analyze and will be stored at 4°C.

[c] Target PAHs include anthracene, pyrene, dibenzofuran, benzo(g,h,i)perylene, indeno(1,2,3-cd)pyrene, perylene, benzo(b)fluoranthene, fluoranthene, benzo(k)fluoranthene, acenaphthylene, chrysene, benzo(a)pyrene, dibenz(a,h)anthracene, benzo(a)anthracene, acenaphthene, phenanthrene, fluorene, 1-methylnaphthalene, naphthalene, and 2-methylnaphthalene.

[d] Antimony, arsenic, cadmium, chromium, cobalt, copper, lead, molybdenum, nickel, silver, thallium, vanadium, and zinc.

[e] Sediment may be frozen, with a maximum holding time of 6 months.

CVAA – cold vapor atomic absorption
EPA – US Environmental Protection Agency
GC/ECD – gas chromatography/electron capture detection
GC/FPD – gas chromatography/flame photometric detection
GC/MS – gas chromatography/mass spectrometry
GFAAS – graphite furnace atomic absorption spectrophotometry
ICP-AES – inductively coupled plasma-atomic emission spectrometry
ICP-MS – inductively coupled plasma-mass spectrometry
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
PSEP – Puget Sound Estuary Program
TOC – total organic carbon

3.5.2 Data quality indicators

The parameters used to assess data quality are precision, accuracy, representativeness, comparability, completeness, and sensitivity. Table 3-8 list specific DQIs for the laboratory analysis of all samples. Target MDLs and RLs are presented in Appendices C and D for tissue and sediment, respectively. These parameters are discussed in greater detail in the following sections.

Table 3-8. Data quality indicators for chemical analyses

Parameter	Precision (laboratory replicates)	Accuracy		Completeness
		Instrument Calibration (% difference)	Spiked Samples (% recovery)	
PCBs as Aroclors	±50%	±25	laboratory QC limits[a]	95%
PAHs	±50%	±25	laboratory QC limits[a]	95%
Butyltins	±50%	±15	laboratory QC limits[a]	95%
Total mercury	±30%	±20	75 – 125%	95%
Other total metals	±30%	±10	75 – 125%	95%
Lipids	±30%	na	na	95%
Grain size	±30%	na	na	95%
Total solids	±20%	na	na	95%
TOC	±30%	na	laboratory QC limits[a]	95%

[a] The laboratory's performance-based control limits that are in effect at the time of analysis will be used as accuracy limits for LCS and MS/MSD samples.

na – not applicable

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

QC – quality control

TOC – total organic carbon

3.5.2.1 Precision

Precision is the measure of the reproducibility among individual measurements of the same property, usually under similar conditions, such as multiple measurements of the same sample. Precision is assessed by performing multiple analyses on a sample and is expressed as an RPD when duplicate analyses are performed and as %RSD when more than two analyses are performed on the same sample (e.g., triplicates). Precision is assessed by laboratory duplicate analyses (i.e., laboratory replicate samples, MS/MSD, LCS duplicates) for all parameters except when reference materials are not available or spiking of the matrix is inappropriate. In these cases, precision is assessed by laboratory triplicate analyses. Precision measurements can be affected by the nearness of a chemical concentration to the MDL, which causes the percent error (expressed as either %RSD or RPD) to increase. The DQI for precision varies depending on the analyte. The equations used to express precision are as follows:

$$RPD = \frac{(\text{measured conc} - \text{measured duplicate conc})}{(\text{measured conc} + \text{measured duplicate conc}) \div 2} \times 100$$ **Equation 1**

$$\%RSD = (SD/D_{ave}) \times 100$$ **Equation 2**

where:

$$SD = \sqrt{\left(\frac{\left(\sum Dn - D_{ave}\right)^2}{(n-1)}\right)}$$

SD = standard deviation
D = sample concentration
D_{ave} = average sample concentration
n = number of samples

3.5.2.2 Accuracy

Accuracy is an expression of the degree to which a measured or computed value represents the true value. Accuracy may be expressed as a percentage recovery for MS and LCS analyses. The DQI for accuracy varies, depending on the analyte (Table 3-9). The equation used to express accuracy for spiked samples is as follows:

$$\text{Percent recovery} = \frac{\text{spike sample result} - \text{unspiked sample result}}{\text{amount of spike added}} \times 100$$ **Equation 3**

3.5.2.3 Representativeness

Representativeness expresses the degree to which data accurately and precisely represent an environmental condition. The sampling approach was designed to address the specific objectives described in Section 2.2. Assuming those objectives are met, the samples collected should be considered adequately representative of the environmental conditions they are intended to characterize.

3.5.2.4 Comparability

Comparability expresses the confidence with which one dataset can be evaluated in relation to another dataset. Sample collection and chemical and physical testing will adhere to the most recent PSEP QA/QC procedures (PSEP 1997b) and EPA and PSEP analysis protocols.

3.5.2.5 Completeness

Completeness is a measure of the amount of data that is determined to be valid in proportion to the amount of data collected. Completeness will be calculated as follows:

$$\text{Completeness} = \frac{\text{number of valid measurements}}{\text{total number of data points planned}} \times 100$$ **Equation 4**

The DQI for completeness for all components of this project is 95%. Data that have been qualified as estimated because the QC criteria were not met will be considered

valid for the purpose of assessing completeness. Data that have been qualified as rejected will not be considered valid for the purpose of assessing completeness.

3.5.2.6 Sensitivity

Analytical sensitivity is the minimum concentration of an analyte above which a data user can be reasonably confident that the analyte was reliably detected and quantified.

An analysis was conducted to determine if a lower tissue mass could be collected and still meet the risk-based ACGs described in Appendix C because collecting the standard tissue mass may be difficult in some sampling areas. Invertebrate tissue mass[8]required for analysis is presented in Table 3-9; a total of 45 g of benthic invertebrate tissue will be required per sample to meet the target DQIs. Table 3-9 summarizes the reduced tissue mass and sediment volume needed for each sample type. If insufficient tissue is collected and the target mass cannot be achieved, then alternate strategies will be identified in consultation with EPA, including reduced sample mass with higher RLs for analytes that are likely to be detected based on benthic invertebrate tissue data from similar sites (e.g., Lockheed West and LDW).

Table 3-9. Tissue mass and sediment volume required per analytical method

PARAMETER	METHOD	TISSUE MASS (g)	SEDIMENT VOLUME (oz)
PCB Aroclors	EPA 8082	10	4
PAHs	EPA 8270D	10	8
Tributyltin	Krone et al. (1989)	10	4
Mercury	EPA 7471A	2	2
Other metals[a]	EPA 6010B, 6020, or 7000	3	2
Lipids	NOAA (1993)	5	na
Total solids	PSEP (1997)	5	2
TOC	Plumb, 1981	na	2
Grain size	PSEP (1997)	na	16
Total Mass		**45**	**40**

[a] Antimony, arsenic, cadmium, chromium, cobalt, copper, lead, molybdenum, nickel, silver, vanadium, zinc.

EPA – US Environmental Protection Agency
na – not applicable
NOAA – National Oceanic and Atmospheric Administration
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
PSEP – Puget Sound Estuary Program
TOC – total organic carbon

Appendix D contains an evaluation of the sediment MDLs and RLs relative to risk-based ACGs for the co-located sediment samples to be collected at benthic invertebrate sampling locations.

[8] The required benthic invertebrate tissue mass does not include the weight of the shell.

3.6 QUALITY ASSURANCE/QUALITY CONTROL

The QA/QC criteria for the laboratory analyses are described in the following subsections.

3.6.1 Chemical analyses quality control criteria

Before analyzing the samples, the laboratory must provide written protocols for the analytical methods to be used, calculate MDLs for each analyte in each matrix type, and establish an initial calibration curve for all analytes. The laboratory must demonstrate their continued proficiency through participation in inter-laboratory comparison studies and through repeated analyses of SRMs, calibration checks, method blanks, and spiked samples.

3.6.1.1 Determination of MDLs

The MDL is defined as the lowest concentration of an analyte or compound that a method can detect in either a sample or a blank with 99% confidence. The laboratories determine MDLs using standard procedures outlined in 40CFR136, in which seven or more replicate samples are fortified at 1 to 5 times (but not to exceed 10 times) the expected MDL concentration. The MDL is then determined by calculating the standard deviation of the replicates and multiplying by the Student's t-factor (e.g., 3.14 for seven replicates).

3.6.1.2 Sample delivery group

Project- and/or method-specific QC measures such as MS/MSD or laboratory replicate samples will be analyzed per SDG, preparatory batch, or analytical batch, as specified in Table 3-10. An SDG is defined as no more than 20 samples or a group of samples received at the laboratory within a 2-week period. Although an SDG may span 2 weeks, all holding times specific to each analytical method will be met for each sample in the SDG.

Table 3-10. Laboratory quality control sample analysis summary

Analysis Type	Initial Calibration	Second Source Initial Calibration Verification	Continuing Calibration Verification	Laboratory Control Sample	Laboratory Replicate Sample	Matrix Spike	Matrix Spike Duplicate	Method Blank	Standard Reference Material[a]	Surrogate Spike
PCB Aroclors	prior to analysis	after initial calibration	every 10 to 20 analyses or 12 hrs	1 per prep batch	na	1 per batch or SDG	1 per batch or SDG	1 per prep batch	each batch or SDG	each sample
PAHs	prior to analysis	after initial calibration	every 10 to 20 analyses or 12 hrs	1 per prep batch	na	1 per batch or SDG	1 per batch or SDG	1 per prep batch	each batch or SDG	each sample
Butyltins	prior to analysis	after initial calibration	every 10 samples	1 per prep batch	na	1 per batch or SDG	1 per batch or SDG	1 per prep batch	each batch or SDG	each sample
Mercury	prior to analysis	after initial calibration	every 10 samples	1 per prep batch	1 per batch or SDG	1 per batch or SDG	na	1 per prep batch	each batch or SDG	na
Other metals	prior to analysis	after initial calibration	every 10 samples	1 per prep batch	1 per batch or SDG	1 per batch or SDG	na	1 per prep batch	each batch or SDG	na
Grain size	na	na	na	na	2 per batch or SDG	na	na	na	na	na
TOC	daily	after initial calibration	every 10 samples	1 per prep batch	1 per batch or SDG	1 per batch or SDG	na	1 per prep batch	na	na
Total solids	na	na	na	na	1 per batch or SDG	na	na	1 per prep batch	na	na
Lipids	na	na	na	na	1 per batch or SDG	na	na	na	na	na

Note: A batch is a group of samples of the same matrix analyzed or prepared at the same time, not to exceed 20 samples.

[a] An LCS may be used to assess accuracy when SRM is unavailable (i.e., for tissue matrices).

[b] Aroclor standards will be run as interference check samples for this analysis.

LCS – laboratory control sample
na – not applicable
PCB – polychlorinated biphenyl
PAH – polycyclic aromatic hydrocarbon
SDG – sample delivery group
SRM – standard reference material
TOC – total organic carbon

3.6.1.3 Laboratory quality control criteria

The laboratory analyst's will review the results of QC analyses (described below) of each analytical batch immediately after the samples have been analyzed. The QC sample results will be evaluated to determine whether control limits have been exceeded. If control limits have been exceeded, then appropriate corrective action must be initiated before a subsequent group of samples is processed (e.g., recalibration followed by reprocessing of the affected samples). The project QA/QC coordinator must be contacted immediately by the laboratory PM if satisfactory corrective action to achieve the DQIs outlined in this QAPP is not possible. All laboratory corrective action reports relevant to the analysis of project samples must be included in the data deliverable packages.

All primary chemical standards and standard solutions used in this project will be traceable to the National Institute of Standards and Technology, Environmental Resource Associates, National Research Council of Canada, or other documented, reliable commercial sources. The accuracy of the standards should be verified through comparison with an independent standard. Laboratory QC standards are verified a multitude of ways. Second-source calibration verifications (i.e., same chemicals manufactured by two different vendors) are analyzed to verify initial calibrations. New working standard mixes (e.g., calibrations, spikes) should be verified against the results of the original solution before being put into use and be within 10% of the true value. Newly purchased standards should be verified against current data. Any impurities found in the standard must be documented. The following subsections summarize the procedures that will be used to assess data quality throughout sample analysis.

Laboratory Replicate Samples

Laboratory replicate samples provide information on the precision of the analysis and are useful in assessing potential sample heterogeneity and matrix effects. Laboratory replicates are subsamples of the original sample that are prepared and analyzed as a separate sample, assuming sufficient sample matrix is available. A minimum of one laboratory replicate sample will be analyzed for each SDG or for every 20 samples, whichever is more frequent, for inorganic and conventional parameters.

Matrix Spikes and Matrix Spike Duplicates

The analysis of MS samples provides information on the extraction efficiency of the method on the sample matrix. Through the performance of MSD analyses, information on the precision of the method is also provided for organic analyses. For organic analyses, a minimum of one MS/MSD pair will be analyzed for each SDG, when sufficient sample volume is available. For inorganic analyses (i.e., metals), a minimum of one MS sample will be analyzed for each SDG when sufficient sample volume is available.

Method Blanks

Method blanks are analyzed to assess possible laboratory contamination at all stages of sample preparation and analysis. A minimum of one method blank will be analyzed for each extraction/digestion batch or for every 20 samples, whichever is more frequent.

Standard Reference Material

SRMs are samples of similar matrix and of known analyte concentration that are processed through the entire analytical procedure and used as an indicator of method accuracy. A minimum of one SRM will be analyzed for each SDG or for every 20 samples, whichever is more frequent.

Surrogate Spikes

All samples analyzed for organic compounds will be spiked with appropriate surrogate compounds as defined in the analytical methods.

Laboratory Control Samples

LCSs are prepared from a clean matrix similar to the project samples and are spiked with known amounts of the target compounds. The recoveries of the compounds are used as a measure of the accuracy of the test methods.

Internal Standard Spikes

Internal standard spikes may be used for calibrating and quantifying organic compounds and metals by means of inductively coupled plasma-mass spectrometry. If internal standards are used, all calibration, QC, and project samples will be spiked with the same concentration of the selected internal standard(s). Internal standard recoveries and retention times must be within method and/or laboratory criteria.

Method of Standard Additions

If matrix interferences are found to be present during metals analysis, it may be necessary to compensate for the interferences by performing a method of standard additions (MSA). The MSA technique involves adding known amounts of standard to one or more aliquots of the sample digest. If MSA is performed, a different MSA curve must be generated for each sample. An MSA curve generated for a single sample must not be applied to other samples unless it can be clearly demonstrated that all samples exhibit the same matrix effect.

3.7 INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

Prior to each field event, measures will be taken to test, inspect, and maintain all field equipment. All equipment, including the DGPS unit and digital camera, will be tested for use before leaving for the field event.

The FC will be responsible for overseeing the testing, inspection, and maintenance of all field equipment. The laboratory PM will be responsible for ensuring that laboratory equipment testing, inspection, and maintenance requirements are met.

3.8 INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY

Multipoint initial calibrations will be performed on each instrument prior to sample analysis, after each major interruption to the analytical instrument, and when more than one continuing calibration verification sample does not meet the specified criteria. The number of points used in the initial calibration is defined in each analytical method. Continuing calibration verifications will be performed daily for organic analyses, once every 10 samples for the inorganic analyses, and with every sample batch for conventional parameters to ensure proper instrument performance.

Gel permeation chromatography calibration verifications will be performed at least once every 7 days, and corresponding raw data will be submitted by the laboratory with the data package. In addition, florisil performance checks will be performed for every florisil lot, and the resulting raw data will be submitted with the data package, when applicable.

The calibration of analytical equipment used for chemical analysis includes instrument blanks or continuing calibration blanks, which provide information on the stability of the instrument's baseline. Continuing calibration blanks will be analyzed immediately after the continuing calibration verification at a frequency of one blank for every 10 samples analyzed for metals analyses and one blank for every 12 hours for organic analyses. If the continuing calibration blank does not meet the specified criteria, the analysis must be discontinued. The analysis may be resumed after corrective actions have been taken to meet the method specifications. All project samples analyzed by an instrument found to be out of compliance must be reanalyzed. None of the field equipment requires calibration.

3.9 INSPECTION/ACCEPTANCE OF SUPPLIES

The field team leaders for each sampling event will have a checklist of supplies required for each day in the field (see Section 3.2.5). The FC will gather and check these supplies daily for satisfactory conditions before each field event. Batteries used in the DGPS unit and digital camera will be checked daily and recharged as necessary. Supplies for field sampling will be inspected upon delivery and accepted if the condition of the supplies is satisfactory. For example, jars will be inspected to ensure that they are of the correct size and quantity and have not been damaged in shipment.

3.10 DATA MANAGEMENT

All field data will be recorded on field forms (see Appendix B), which will be checked for missing information by the FC at the end of each field day and amended as necessary. After sampling has been completed, all data from field forms will be entered into a Microsoft Excel® spreadsheet for import into the project database. A secondary QC check will be done to ensure that 100% of the data were properly transferred from the field forms to the spreadsheet. This spreadsheet will be kept on the Windward network server, which is backed up daily. Field forms will be archived

in the Windward library. All photographs will be transferred to the secure network or a CD at the end of the sampling effort.

Field sampling and analytical information will be submitted to the EPA's Analytical Services Tracking System (ANSETS) no later than the 15th of the month after sampling activities have occurred and the sampling compositing and analysis scheme have been approved. The project QA/QC coordinator will be responsible for the submitting the required information to ANSETS.

Analytical laboratories are expected to submit data in an electronic format as described in Section 2.6.2. The laboratory PM will contact the project QA/QC coordinator prior to data delivery to discuss specific format requirements.

A library of routines will be used to translate typical electronic output from laboratory analytical systems and to generate data analysis reports. The use of automated routines ensures that all data are consistently converted into the desired data structures and that operator time is kept to a minimum. In addition, routines and methods for quality checks will be used to ensure such translations are correctly applied.

Written documentation will be used to clarify how field and analytical laboratory duplicates and QA/QC samples were recorded in the data tables and to provide explanations of other issues that may arise. The data management task will include keeping accurate records of field and laboratory QA/QC samples so that project team members who use the data will have appropriate documentation. Data management files will be stored on a secure computer.

4 Assessment and Oversight

4.1 Compliance Assessments and Response Actions

EPA or other management agencies may observe field activities during each sampling event, as needed. If situations arise in which there is an inability to follow QAPP methods precisely, the Windward PM will determine the appropriate actions or consult EPA if the issue is significant.

4.1.1 Compliance assessments

Laboratory and field performance assessments consist of EPA-conducted onsite reviews of QA systems and equipment for sampling, calibration, and measurement. EPA personnel may conduct a laboratory audit prior to sample analysis. Any pertinent laboratory audit reports will be made available to the project QA/QC coordinator upon request. Analytical and taxonomy laboratories are required to have written procedures that address internal QA/QC; these procedures will be submitted for review by the project QA/QC coordinator upon request to ensure compliance with the

QAPP. All laboratories and QA/QC coordinators are required to ensure that all personnel engaged in sampling and analysis tasks have appropriate training.

4.1.2 Response actions for field sampling

The FC, or a designee, will be responsible for correcting equipment malfunctions throughout field sampling and for resolving situations in the field that may result in nonconformance or noncompliance with the QAPP. All corrective measures will be immediately documented in the field logbook, and protocol modification forms will be completed.

4.1.3 Corrective action for laboratory analyses

Analytical laboratories are required to comply with their current written standard operating procedures, laboratory QA plan, and analytical methods. All laboratory personnel will be responsible for reporting problems that may compromise the quality of the data. Laboratory personnel will identify and correct any anomalies before continuing with sample analysis. The laboratory PMs will be responsible for ensuring that appropriate corrective actions are initiated, as required, for conformance with this QAPP.

The project QA/QC coordinator will be notified immediately if any QC parameter exceeds the project DQIs outlined in this QAPP (Table 3-8) and cannot be resolved through standard corrective action procedures. A description of the anomaly, the steps taken to identify and correct the anomaly, and the treatment of the relevant sample batch (i.e., recalculation, reanalysis, and re-extraction) will be submitted with the data package using the case narrative or corrective action form.

4.2 REPORTS TO MANAGEMENT

Progress reports will be prepared by the FC for submittal to the EWG and EPA following each sampling event. The project QA/QC coordinator will also prepare progress reports after the sampling is completed and samples have been submitted for analysis, when information is received from the laboratory, and when analyses are complete. The status of the samples and analyses will be indicated with emphasis on any deviations from the QAPP. A data report will be written after validated data are available for each sampling event, as described in Section 2.6.4.

5 Data Validation and Usability

5.1 DATA VALIDATION

The laboratory analyst is responsible for ensuring that the analytical data are correct and complete, that appropriate procedures have been followed, and that QC results are within the acceptable limits. The data validation process begins at the laboratory with the review and evaluation of data by supervisory personnel or QA specialists.

The project QA/QC coordinator is responsible for ensuring that all analyses performed by the laboratory are correct, properly documented, and complete, and that they satisfy the project DQOs specified in this QAPP.

Data are not considered final until validated. Data validation will be conducted following EPA guidance (1999; 2004). Independent third-party data review and summary validation of the analytical chemistry data will be conducted by EcoChem. A minimum of 20% of sample results or a single SDG will undergo full data validation. Full data validation parameters include:

- Quality control analysis frequencies
- Analysis holding times
- Laboratory blank contamination
- Instrument calibration
- Surrogate recoveries
- LCS recoveries
- MS recoveries
- MS/MSD RPDs
- Compound identifications
- Compound quantitations
- Instrument performance checks (i.e., tune ion abundances)
- Internal standard areas and retention time shifts

If no discrepancies are found between reported results and raw data in the set that undergoes full data validation, validation can proceed as a summary-level data validation on the rest of the data using all the QC forms submitted in the laboratory data package. QA review of the sediment and tissue chemistry data will be performed in accordance with the QA requirements of the project; the technical specifications of the analytical methods indicated in Tables 3-6, 3-7, and 3-8; and EPA guidance for organic and inorganic data review (EPA 2004, 1999). The EPA PM may have EPA peer review the third-party validation or perform data assessment/validation on a percentage of the data.

All discrepancies and requests for additional, corrected data will be discussed with the laboratory prior to issuing the formal data validation report. The project QA/QC coordinator should be informed of all contacts with the laboratory during data validation. Review procedures used and findings made during data validation will be documented on worksheets. The data validator will prepare a data validation report that will summarize QC results, qualifiers, and possible data limitations. Only validated data with appropriate qualifiers will be released for use in the EW SRI/FS. Rejected data will not be used for any purpose.

5.2 RECONCILIATION WITH DATA QUALITY OBJECTIVES

Data quality assessment will be conducted by the project QA/QC coordinator. The results of the third-party independent review and validation will be reviewed, and cases where the projects DQOs were not met will be identified. The usability of the data will be determined in terms of the magnitude of the DQO exceedance.

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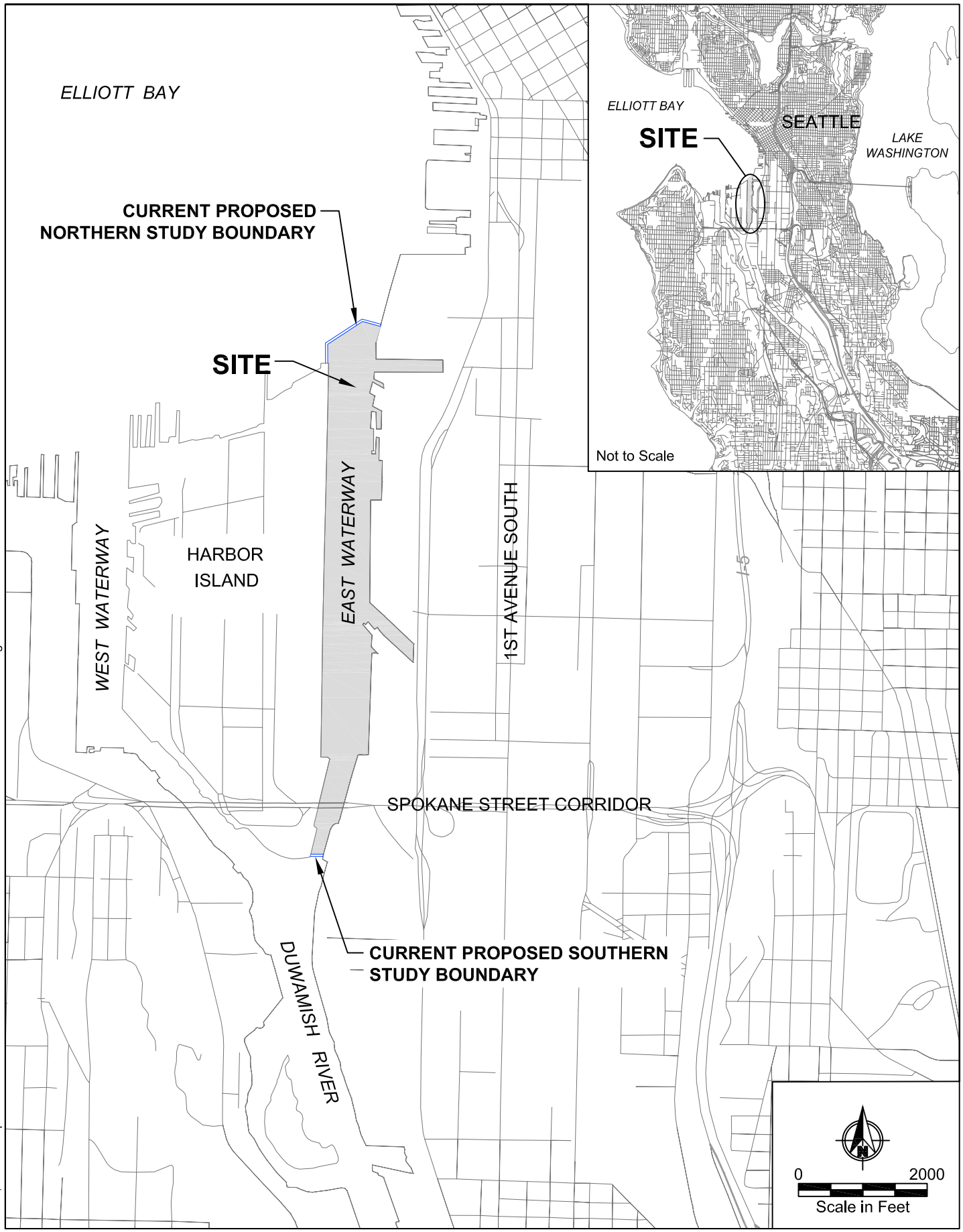
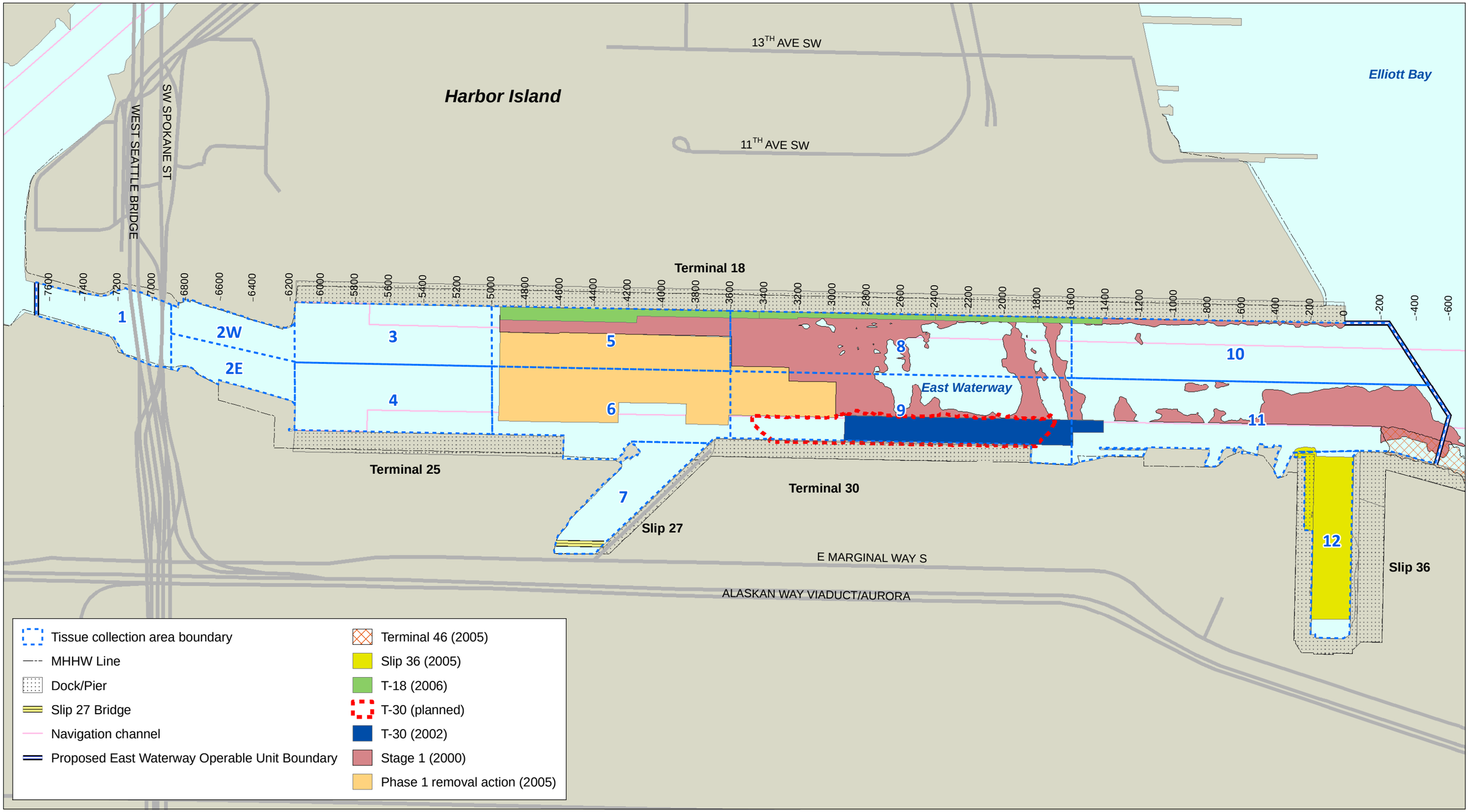
7 Maps



Jul 08, 2008 1:38pm cdavidson K:\Jobs\060003-PORT OF SEATTLE\060003-01\06000301-040.dwg FIG 2-1

Map 2-1
Vicinity Map
East Waterway Operable Unit



Wind Ward environmental LLC

Map 3-1. Proposed infaunal tissue collection areas

APPENDIX A

Health and Safety Plan

EAST WATERWAY OPERABLE UNIT
SUPPLEMENTAL REMEDIAL INVESTIGATION/ FEASIBILITY STUDY
HEALTH AND SAFETY PLAN
BENTHIC INVERTEBRATE TISSUE/GASTROPOD COLLECTION

For submittal to:

The US Environmental Protection Agency
Region 10
Seattle, WA

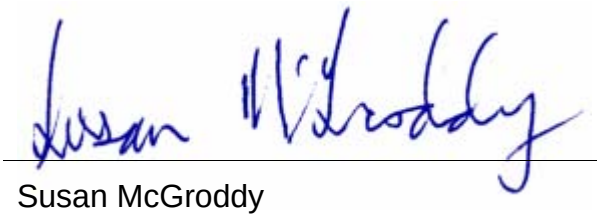
October 10, 2008

Prepared by: Wind Ward environmental LLC

200 West Mercer Street, Suite 401 ♦ Seattle, Washington ♦ 98119

Health and Safety Plan

By their signature, the undersigned certify that this health and safety plan is approved and that it will be used to govern health and safety aspects of fieldwork described in the quality assurance project plan to which it is attached.



October 10, 2008

Susan McGroddy — Date

Project Manager

October 10, 2008

Tad Deshler — Date

Corporate Health and Safety Manager

October 10, 2008

Helle Andersen — Date

Field Coordinator/Health and Safety Officer

Table of Contents

List of Tables

Acronyms

CFR	Code of Federal Regulations
CPR	cardiopulmonary resuscitation
EW	East Waterway
FC	field coordinator
HAZWOPER	Hazardous Waste Operations and Emergency Response
HSM	health and safety manager
HSO	health and safety officer
HSP	health and safety plan
OSHA	Occupational Safety and Health Administration
PAH	polycyclic aromatic hydrocarbon
PCBs	polychlorinated biphenyls
PEC	project emergency coordinator
PFD	personal flotation device
PM	project manager
PPE	personal protective equipment
QAPP	quality assurance project plan
TCDD	tetrachlorodibenzo-*p*-dioxin
USCG	US Coast Guard

1 Introduction

This site-specific health and safety plan (HSP) describes safe working practices for conducting field activities at potentially hazardous sites and for handling potentially hazardous materials/waste products. This HSP covers elements as specified in 29 CFR 1910§120. The goal of the HSP is to establish procedures for safe working practices for all field personnel.

This HSP addresses all activities associated with collection and handling of benthic invertebrates and sediment in the East Waterway (EW). During site work, this HSP will be implemented by the field coordinator (FC), who is also the designated site health and safety officer (HSO), in cooperation with the corporate health and safety manager (HSM) and the project manager (PM).

All personnel involved in fieldwork on this project are required to comply with this HSP. The contents of this HSP reflect anticipation of the types of activities to be performed, knowledge of the physical characteristics of the site, and consideration of preliminary chemical data from previous investigations at the site. The HSP may be revised based on new information and/or changed conditions during site activities. Revisions will be documented in the project records.

2 Site Description and Project Scope

2.1 SITE DESCRIPTION

The sampling area is in the EW (see Map 3-1 in the quality assurance project plan [QAPP] to which this HSP is attached). The area is affected by tidal fluctuations. The QAPP provides complete details of the sampling program.

2.2 SCOPE AND DURATION OF WORK

This section summarizes the types of work that will be performed during field activities. Specific tasks to be performed are as follows:

- Collection of biological specimens from a boat using a van Veen grab sampler and benthic sledge
- Collection of sediment samples from a boat using a van Veen grab sampler
- Sample handling, processing, and shipping

The collection of biological specimens and sediment samples is anticipated to occur in October 2008 as described in the QAPP.

3 Health and Safety Personnel

Key health and safety personnel and their responsibilities are described below. These individuals are responsible for the implementation of this HSP.

Project Manager: The PM has overall responsibility for the successful outcome of the project. The PM will ensure that adequate resources and budget are provided for the health and safety staff to carry out their responsibilities during fieldwork. The PM, in consultation with the HSM, makes final decisions concerning implementation of the HSP.

Field Coordinator/Health and Safety Officer: Because of the limited scope and duration of fieldwork, the FC and HSO will be the same person. The FC/HSO will direct field sampling activities, coordinate the technical components of the field program with health and safety components, and ensure that work is performed according to the QAPP. The FC/HSO will implement this HSP at the work location and will be responsible for all health and safety activities and the delegation of duties to a health and safety technician in the field, if appropriate. The FC/HSO also has stop-work authority, to be used if there is an imminent safety hazard or potentially dangerous situation. The FC/HSO or his designee shall be present during sampling and operations.

Corporate Health and Safety Manager: The HSM has overall responsibility for the preparation, approval, and revision of this HSP. The HSM will not necessarily be present during fieldwork but will be readily available, if required, for consultation regarding health and safety issues during fieldwork.

Field Crew: All field crew a members must be familiar and comply with the information in this HSP. They also have the responsibility to immediately report any potentially unsafe or hazardous conditions to the FC/HSO.

4 Hazard Evaluation and Control Measures

This section discusses potential physical and chemical hazards that may be associated with the proposed project activities and presents control measures for addressing these hazards. The activity hazard analysis (Section 4.4) lists the potential hazards associated with each site activity and the recommended site control to be used to minimize each potential hazard. Confined-space entry will not be necessary for this project. Therefore, hazards associated with this activity are not discussed in this HSP.

4.1 PHYSICAL HAZARDS

For this project, it is anticipated that physical hazards present a greater risk of injury than do chemical hazards. Physical hazards are identified and discussed below.

4.1.1 Slips, trips, and falls

As with all fieldwork sites, caution should be exercised to prevent slips on slick surfaces. In particular, sampling from a boat or other floating platform requires careful attention to minimize the risk of falling down or falling overboard. The same care should be used in rainy conditions or on the shoreline where slick rocks are found. Slips can be minimized through the use of boots with good treads, made of material that does not become overly slippery when wet.

Trips are always a hazard on the uneven deck of a boat, in a cluttered work area, or in the intertidal zone where uneven substrate is common. Personnel will keep work areas as free as possible from items that interfere with walking.

Falls can also be a hazard. Personnel can avoid falls by working as far from exposed edges as possible, erecting railings, and using fall protection when working on elevated platforms. For this project, no work that would present a fall hazard is anticipated.

4.1.2 Sampling equipment

A van Veen grab sampler and benthic sledge will be used to collect benthic sediment as described in Section 3.2 of the QAPP. After sieving the sediment, benthic tissue will be collected using stainless steel forceps. Before sampling activities begin, all personnel will attend a training session to discuss the equipment that will be onboard the sampling vessel.

4.1.3 Falling overboard

The sampling activities will be performed on a boat. As with any work from a floating platform, there is a chance of falling overboard. Personal flotation devices (PFDs) will be worn by all personnel while working from the boat.

4.1.4 Manual lifting

Equipment and samples must be lifted and carried. Back strain can result if lifting is done improperly. During any manual handling tasks, personnel should lift with the load supported by their legs and not their backs. For heavy loads, an adequate number of people will be used, or if possible, a mechanical lifting/handling device will be used.

4.1.5 Heat stress, hypothermia, or frostbite

Sampling operations and conditions that might result in heat stress, hypothermia, or frostbite are not anticipated. Sampling will occur during the time of year when extreme weather conditions are not expected to occur.

4.1.6 Weather

In general, field team members will be equipped for the normal range of weather conditions. The FC/HSO will be aware of current weather conditions and of the potential for those conditions to pose a hazard to the field crew. Some conditions that might force work stoppage are electrical storms, high winds, or high waves resulting from winds.

4.1.7 Sharp objects

Sampling operations might result in the exposure of field personnel to sharp objects on top of or buried within the sediment. If these objects are encountered, field personnel should not touch them. Also, field personnel should not dig in the sediment by hand.

4.2 VESSEL HAZARDS

Because of the high volumes of vessel and barge traffic on the EW, precautions and safe boating practices will be implemented to ensure that the field boat does not interrupt vessel traffic. Additional potential vessel emergency hazards and responses are listed in Table 1.

Table 1. Potential vessel emergency hazards and responses

POTENTIAL EMERGENCY OR HAZARD	RESPONSE
Fire or explosion	If manageable, personnel should attempt to put out a small fire with a fire extinguisher. Otherwise, personnel should call the USCG or 911 and evacuate the area (by rescue boat or swimming) and meet at a designated area. The FC/HSO will take roll call to make sure everyone evacuated safely. Emergency meeting places will be determined in the field during the daily safety briefing.
Medical emergency or injury	At least one person with current first aid and CPR training will be aboard the vessel at all times. This person will attempt to assess the nature and severity of the injury, immediately call 911, and perform CPR if necessary. Personnel should stop work and wait for medical personnel to arrive. Once the emergency has passed, the FC/HSO should fill out a site accident report.
Person overboard	All personnel aboard the sampling vessel will wear PFDs at all times. One person should keep an eye on the individual who fell overboard and shout the distance (boat lengths) and direction (o'clock) of the individual from the vessel. Personnel should stop work and use the vessel to retrieve the individual in the water.
Sinking vessel	Personnel should call the USCG immediately. If possible, personnel should wait for a rescue boat to arrive to evacuate vessel personnel. See fire or explosion (above) for emergency evacuation procedures. The FC/HSO will take a roll call to make sure everyone is present.
Lack of visibility	If navigation visibility or personal safety is compromised because of smoke, fog, or other unanticipated hazards, personnel should stop work immediately. The vessel operator and FC/HSO will assess the hazard and, if necessary, send out periodic horn blasts to mark vessel location to other vessels potentially in the area, move to a secure location (i.e., berth), and wait for the visibility to clear.

POTENTIAL EMERGENCY OR HAZARD	RESPONSE
Loss of power	Personnel should stop work and call the USCG for assistance. Personnel should use oars to move vessel towards the shoreline. Other vessel personnel should watch for potential collision hazards and notify the vessel operator if hazards exist. Personnel should secure the vessel to a berth, dock, or mooring as soon as possible.
Collision	Personnel should stop work and call the USCG for assistance. The FC/HSO and vessel operator will assess damage and potential hazards. If necessary, the vessel will be evacuated and secured until repairs can be made.

CPR – cardiopulmonary resuscitation
FC – field coordinator
HSO – health and safety officer
PFD – personal flotation device
USCG – US Coast Guard

4.3 CHEMICAL HAZARDS

Previous investigations have shown that some chemical substances are present at higher-than-background concentrations in the sampling area. For the purpose of discussing potential exposure to substances in sediments, the chemicals of concern are metals, tributyltin, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and dioxins and furans.

4.3.1 Exposure routes

Potential routes of chemical exposure include inhalation, dermal contact, and ingestion. Exposure will be minimized by using safe work practices and by wearing the appropriate personal protective equipment (PPE). Further discussion of PPE requirements is presented in Section 7.

Inhalation —Inhalation is not expected to be an important route of exposure for this project.

Dermal exposure — Dermal exposure to hazardous substances associated with sediments, surface water, or equipment decontamination will be controlled through the use of PPE and by adherence to detailed sampling and decontamination procedures.

Ingestion — Ingestion is not considered a major route of exposure for this project. Accidental ingestion of surface water is possible. However, careful handling of equipment and containers aboard the boat should prevent the occurrence of water splashing or spilling during sample collection and handling activities.

4.3.2 Description of chemical hazards

Metals and tributyltin — Exposure to metals may occur via ingestion or skin contact. As mentioned above, neither is likely as an exposure route. Metal fumes or metal-contaminated dust will not be encountered during field and sample handling activities. Large amounts of sediment would need to be ingested for any detrimental

effects to occur. Momentary skin contact allows little, if any, opportunity for the passage of any of the metals into the body. Field procedures require immediate washing of sediments from exposed skin.

Polycyclic aromatic hydrocarbons — Exposure to PAHs may occur via ingestion or skin contact. The most important human health exposure pathway for this group of chemicals, inhalation, is not expected to occur at this site. Animal studies have shown that PAHs can cause harmful effects on skin, body fluids, and the ability to fight disease after both short- and long-term exposure, but these effects have not been documented in people. Some PAHs may reasonably be expected to be carcinogens. Large amounts of sediment would need to be ingested for any detrimental effects to occur. Momentary skin contact allows little, if any, opportunity for passage of any of the compounds into the body. Field procedures require immediate washing of sediments from exposed skin.

Polychlorinated biphenyls — Prolonged skin contact with PCBs may cause acne-like symptoms known as chloracne. Irritation to eyes, nose, and throat may also occur. Acute and chronic exposure can damage the liver, and cause symptoms of edema, jaundice, anorexia, nausea, abdominal pains, and fatigue. PCBs are a suspected human carcinogen. Skin absorption may substantially contribute to the uptake of PCBs. Large amounts of sediment would need to be ingested for any detrimental effects to occur. Momentary skin contact allows little, if any, opportunity for the passage of any of these compounds into the body. Field procedures require the immediate washing of sediments from exposed skin.

Dioxins/furans — Prolonged skin contact with dioxins/furans may cause acne-like symptoms known as chloracne. Other effects to the skin, such as red skin rashes, have been reported to occur in people following exposure to high concentrations of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD). Acute and chronic exposure can damage the liver, result in an increase in the risk of diabetes and abnormal glucose tolerance, and may increase the risk for reproductive and developmental effects. 2,3,7,8-TCDD is a possible human carcinogen, and a mixture of dioxins/furans with six chlorine atoms (four of the six chlorine atoms at the 2-, 3-, 7-, and 8-positions) is a probable human carcinogen. Skin absorption may substantially contribute to the uptake of dioxins/furans. Large amounts of sediment would need to be ingested for any detrimental effects to occur. Momentary skin contact allows little, if any, opportunity for the passage of any of the compounds into the body. Field procedures require the immediate washing of sediments from exposed skin.

4.4 ACTIVITY HAZARD ANALYSIS

The activity hazard analysis summarizes the field activities to be performed during the project, outlines the hazards associated with each activity, and presents controls that can reduce or eliminate the risk of the hazard occurring.

Table 2 presents the activity hazard analysis for sampling from a boat, sieving sediments, and collecting benthic invertebrates from sediment:

Table 2. Activity hazard analysis

ACTIVITY	HAZARD	CONTROL
Sampling from a boat	falling overboard	Use care in boarding and departing from vessel. Wear a PFD.
	skin contact with contaminated sediments or liquids	Wear modified Level D PPE.
	back strain	Use appropriate lifting technique when transporting equipment and supplies to/from the boat, or seek help.
Sieving sediment	skin contact with contaminated sediments or liquids	Wear modified Level D PPE.
	back strain	Use appropriate lifting technique when transporting equipment and supplies to/from the boat, or seek help.
Collecting benthic invertebrates from sediment	skin contact with contaminated sediments or liquids	Wear modified Level D PPE.

PFD – personal flotation device
PPE – personal protective equipment

5 Work Zones and Shipboard Access Control

During sampling and sample handling activities, work zones will be established to identify where sample collection and processing are actively occurring. The intent of the zone is to limit the migration of sample material out of the zone and to restrict access to active work areas by defining work zone boundaries.

5.1 WORK ZONE

The work zone will encompass the area where sample collection and handling activities are performed. The FC/HSO will delineate the work zone as a particular area on-board the collection vessels. Only persons with appropriate training, PPE, and authorization from the FC/HSO will be allowed to enter the work zone while work is in progress.

5.2 DECONTAMINATION STATION

A decontamination station will be set up, and personnel will clean soiled boots or PPE prior to leaving the work zone. The station will have the buckets, brushes, soapy water, rinse water, or wipes necessary to clean boots, PPE, or other equipment leaving the work zones. Plastic bags will be provided for expendable and disposable materials. If the location does not allow for the establishment of a decontamination station, the FC/HSO will provide alternatives to prevent the spread of contamination.

Decontamination of the boat will also be completed at the end of each work day. Cockpit and crew areas will be rinsed down with site water to minimize the accumulation of sediment.

5.3 ACCESS CONTROL

Boat security and access control will be the responsibility of the FC/HSO and boat captain. Boat access will be granted only to essential project personnel and authorized visitors. Any security or access control problems will be reported to the PM or appropriate authorities.

6 Safe Work Practices

Following common sense rules will minimize the risk of exposure or accidents at the work site. These general safety rules will be followed onsite:

- Do not climb over or under obstacles of questionable stability.
- Do not eat, drink, smoke, or perform other hand-to-mouth transfers in the work zone.
- Work only in well-lighted spaces.
- Never enter a confined space without the proper training, permits, and equipment.
- Make eye contact with equipment operators when moving within the range of their equipment.
- Be aware of the movements of shipboard equipment when not in the operator's range of vision.
- Get immediate first aid for all cuts, scratches, abrasions, or other minor injuries.
- Use the established sampling and decontamination procedures.
- Always use the buddy system.
- Be alert to your own and other workers' physical condition.
- Report all accidents, no matter how minor, to the FC/HSO.
- Do not do anything dangerous or unwise even if ordered by a supervisor.

7 Personal Protective Equipment and Safety Equipment

Appropriate PPE will be worn as protection against potential hazards. In addition, a PFD will be required for all personnel when working aboard the boat. Prior to donning PPE, the field crew will inspect their PPE for any defects that might render the equipment ineffective.

Fieldwork will be conducted in Level D or modified Level D PPE, as discussed in Sections 7.1 and 7.2. Situations that would require PPE beyond modified Level D are not anticipated. Should the FC/HSO determine that PPE beyond modified Level D is necessary, the HSM will be notified and an alternative PPE selected.

7.1 LEVEL D PERSONAL PROTECTIVE EQUIPMENT

Individuals performing general activities in which skin contact with contaminated materials is unlikely will wear Level D PPE. Level D PPE includes the following:

- Cotton overalls or lab coats
- Chemical-resistant steel-toed boots
- Chemical-resistant gloves
- Safety glasses

7.2 MODIFIED LEVEL D PERSONAL PROTECTIVE EQUIPMENT

Individuals performing activities in which skin contact with contaminated materials is possible but inhalation risks are not expected will be required to wear an impermeable outer suit. The type of outerwear will be chosen according to the types of chemical contaminants that might be encountered. Modified Level D PPE includes the following:

- Impermeable outer garb, such as rain gear
- Chemical-resistant steel-toed boots
- Chemical-resistant outer gloves

7.3 SAFETY EQUIPMENT

In addition to the above-identified PPE, basic emergency and first aid equipment will also be provided. Equipment for the field team will include:

- A copy of this HSP
- First aid kit adequate for the number of personnel in the field crew
- Emergency eyewash

The FC/HSO will ensure that the safety equipment is available. Equipment will be checked daily to ensure its readiness for use.

8 Monitoring Procedures for Site Activities

A monitoring program that addresses the potential site hazards will be implemented. For this project, air, dust, and noise monitoring will not be necessary. No volatile organic compounds have been identified among the expected contaminants, the sampled media will be wet and will not pose a dust hazard, and none of the

equipment emits high-amplitude (i.e., > 85 dBA) noise. For this project, the monitoring program will consist of all individuals monitoring themselves and their co-workers for signs of potential physical stress or illness.

All personnel will be instructed to look for and inform each other of any deleterious changes in their physical or mental conditions during the performance of all field activities. Examples of such changes are as follows:

- Headaches
- Dizziness
- Nausea
- Symptoms of heat stress
- Blurred vision
- Cramps
- Irritation of eyes, skin, or respiratory system
- Changes in complexion or skin color
- Changes in apparent motor coordination
- Increased frequency of minor mistakes
- Excessive salivation or changes in papillary response
- Changes in speech ability or speech pattern
- Shivering
- Blue lips or fingernails

If any of these conditions develop, work will be halted immediately and the affected person(s) evaluated. If further assistance is needed, personnel at the local hospital will be notified, and an ambulance will be summoned if the condition is thought to be serious. If the condition is the direct result of sample collection or handling activities, procedures will be modified to address the problem.

9 Decontamination

Decontamination is necessary to prevent the migration of contaminants from the work zone(s) into the surrounding environment and to minimize the risk of exposure of personnel to contaminated materials that might adhere to PPE. The following sections discuss personnel and equipment decontamination. The following supplies will be available to perform decontamination activities:

- Wash buckets
- Rinse buckets

- Long-handled scrub brushes
- Clean water sprayers
- Paper towels
- Plastic garbage bags
- Alconox® or similar decontamination solution

9.1 MINIMIZATION OF CONTAMINATION

The first step in addressing contamination is to prevent or minimize exposure to existing contaminated materials and the spread of those materials. During field activities, the FC/HSO will enforce the following measures:

Personnel:

- Do not walk through areas of obvious or known contamination.
- Do not handle, touch, or smell contaminated materials directly.
- Make sure PPE has no cuts or tears prior to use.
- Fasten all closures on outer clothing, covering with tape if necessary.
- Protect and cover any skin injuries.
- Stay upwind of airborne dusts and vapors.
- Do not eat, drink, chew tobacco, or smoke in the work zones.

Sampling equipment and boat:

- Place clean equipment on a plastic sheet or aluminum foil to avoid direct contact with contaminated media.
- Keep contaminated equipment and tools separate from clean equipment and tools.
- Clean boots before entering the boat.

9.2 PERSONNEL DECONTAMINATION

The FC/HSO will ensure that all site personnel are familiar with personal decontamination procedures. Personnel will perform decontamination procedures, as appropriate, before eating lunch, taking a break, or leaving the work location. Decontamination procedures for field personnel include:

1. Rinse off the outer suit if it is heavily soiled.
2. Wash and rinse outer gloves and boots with water.
3. Remove and inspect outer gloves and discard them if damaged.
4. Wash hands if taking a break.

5. Don necessary PPE before returning to work.
6. Dispose of soiled, disposable PPE before leaving for the day.

In addition to the decontamination procedures listed above, divers will:

1. Thoroughly rinse dive suit and gear after each dive.
2. Inspect gear for mud or stains, and re-rinse or scrub with Alconox®, if necessary.
3. Discard any damaged or heavily soiled gear after the project, if necessary.
4. Launder dry suit underwear after the project.

9.3 SAMPLING EQUIPMENT DECONTAMINATION

Sampling equipment will be decontaminated to minimize sample contamination. The practices listed below will be followed:

- Caught specimens will be placed only on clean surfaces, such as aluminum foil (dull side touching the specimen).
- Ice chests will be scrubbed with Alconox® detergent and rinsed with deionized water prior to any sampling activities.
- Samples will be placed in clean, laboratory certified sample jars, or resealable, waterproof plastic bags to avoid contamination from melting ice.
- Sampling equipment will be free from contaminants such as oils, grease, and fuels.
- All utensils or equipment used directly in handling specimens or sediment samples will be scrubbed with Alconox® detergent and rinsed with deionized water, and stored in aluminum foil until use.

9.4 VESSEL DECONTAMINATION

Some sampling will be conducted from a boat. Care will be taken to minimize the amount of sediment spilled on the vessel. The vessel deck will be hosed off regularly to remove sediment from the cockpit and crew areas to minimize slipping hazards and sediment transport on boots through work zones.

10 Disposal of Contaminated Materials

Contaminated materials that may be generated during field activities include PPE, decontamination fluids, and excess sample material. These contaminated materials will be disposed of as an integral part of the project.

10.1 PERSONAL PROTECTIVE EQUIPMENT

Gross surface contamination will be removed from PPE. All disposable sampling materials and PPE, such as disposable coveralls, gloves, and paper towels used in sample processing, will be placed in heavyweight garbage bags. Filled garbage bags will be placed in a normal refuse container for disposal as solid waste.

10.2 EXCESS SAMPLE MATERIALS

At each sampling location, all excess or unwanted specimens and sediment will be returned to the site.

11 Training Requirements

Individuals performing work at locations where potentially hazardous materials and conditions may be encountered must meet specific training requirements. It is not anticipated that hazardous concentrations of contaminants will be encountered in sampled material, so training will consist of site-specific instruction for all personnel and the oversight of inexperienced personnel by an experienced person for one working day. The following sections describe the training requirements for this fieldwork.

11.1 PROJECT-SPECIFIC TRAINING

In addition to Hazardous Waste Operations and Emergency Response (HAZWOPER) training, as described in Section 2.4 of the QAPP, field personnel will undergo training specifically for this project. All personnel must read this HSP and be familiar with its contents before beginning work. Personnel will acknowledge reading the HSP by signing the Field Team Health and Safety Plan Review Form (Attachment 2). The completed form will be kept in the project files.

Boat operators will also be required to have the US Coast Guard (USCG) auxiliary boating safely certification. The boat captain and FC/HSO or a designee will provide project-specific training prior to the first day of fieldwork and whenever new workers arrive. Field personnel will not be allowed to begin work until project-specific training has been completed and documented by the FC/HSO. Training will address the HSP and all health and safety issues and procedures pertinent to field operations. Training will include, but not be limited to, the following topics:

- Activities with the potential for chemical exposure
- Activities that pose physical hazards and actions to control the hazard
- Ship access control and procedure
- Use and limitations of PPE
- Decontamination procedures

- Emergency procedures
- Use and hazards of sampling equipment
- Location of emergency equipment
- Vessel safety practices
- Emergency evacuation and emergency procedures

11.2 DAILY SAFETY BRIEFINGS

The FC/HSO or a designee and the boat captain will present safety briefings before the start of each day's activities. These safety briefings will outline the activities expected for the day, update work practices and hazards, address any specific concerns associated with the work location, and review emergency procedures and routes. The FC/HSO or designee will document safety briefings in the logbook.

11.3 FIRST AID AND CPR

At least one member of the field team must have first-aid and cardiopulmonary resuscitation (CPR) training. Documentation of which individuals possess first-aid and CPR training will be kept in the project health and safety files.

12 Medical Surveillance

A medical surveillance program conforming to the provisions of 29 CFR 1910§120(f) will not be necessary for field team members because the field team members do not meet any of the four criteria outlined in the regulations for the implementation of a medical surveillance program:

- Employees who are or may be exposed to hazardous substances or health hazards at or above permissible exposure levels for 30 days or more per year (1910.120(f)(2)(I)
- Employees who must wear a respirator for 30 days or more per year (1910.120(f)(2)(ii))
- Employees who are injured or become ill due to possible overexposures involving hazardous substances or health hazards from an emergency response or hazardous waste operation (1910.120(f)(2)(iii))
- Employees who are members of HAZMAT teams (1910.120(f)(2)(iv)).

As described in Section 8, employees will monitor themselves and each other of any deleterious changes in their physical or mental condition during the performance of all field activities.

13 Reporting and Record Keeping

Each member of the field crew will sign the Field Team Health and Safety Plan Review (see Attachment 2). If necessary, accident/incident report forms and Occupational Safety and Health Administration (OSHA) Form 200s will be completed by the FC/HSO.

The FC/HSO or a designee will maintain a health and safety field logbook that records health- and safety-related details of the project. Alternatively, entries may be made in the field logbook, in which case a separate health and safety logbook will not be required. The logbook must be bound, and the pages must be numbered consecutively. Entries will be made with indelible blue ink. At a minimum, each day's entries must include the following information:

- Project name or location
- Names of all personnel
- Weather conditions
- Type of fieldwork being performed

The individual maintaining the entries will initial and date the bottom of each completed page. Blank space at the bottom of an incompletely filled page will be lined out. Each day's entries will begin on the first blank page after the previous workday's entries.

14 Emergency Response Plan

As a result of the hazards and the conditions under which operations will be conducted, the potential exists for an emergency situation to occur. Emergencies may include personal injury, exposure to hazardous substances, fire, explosion, or the release of toxic or non-toxic substances (i.e., spills). OSHA regulations require that an emergency response plan be available to guide actions in emergency situations.

Onshore organizations will be relied upon to provide response in emergency situations. The local fire department and ambulance service can provide timely response. Field personnel will be responsible for identifying emergency situations, providing first aid if applicable, notifying the appropriate personnel or agency, and evacuating any hazardous area. Shipboard personnel will attempt to control only very minor hazards that could present an emergency situation, such as a small fire, and will otherwise rely on outside emergency response resources.

The following sections identify the individual(s) who should be notified in case of emergency, provide a list of emergency telephone numbers, offer guidance for particular types of emergencies, and provide directions for getting from any sampling location to a hospital.

14.1 PRE-EMERGENCY PREPARATION

Before the start of field activities, the FC/HSO will ensure that preparation has been made in anticipation of emergencies. This preparation includes the following:

- Meeting with the FC/HSO and equipment handlers concerning the emergency procedures to be followed in the event of an injury
- Conducting a training session informing all field personnel of emergency procedures, locations of emergency equipment and their use, and proper evacuation procedures
- Conducting a training session (led by senior staff responsible for operating field equipment) to apprise field personnel of operating procedures and specific risks associated with field equipment
- Ensuring that field personnel are aware of the existence of the emergency response plan in the HSP and ensuring that a copy of the HSP accompanies the field team

14.2 PROJECT EMERGENCY COORDINATOR

The FC/HSO will serve as the project emergency coordinator (PEC) in the event of an emergency. She will designate a replacement for times when she is not available or is not serving as the PEC. The designation will be noted in the logbook. The PEC will be notified immediately when an emergency is recognized. The PEC will be responsible for evaluating the emergency situation, notifying the appropriate emergency response units, coordinating access with those units, and directing onboard interim actions before the arrival of emergency response units. The PEC will notify the HSM and the PM as soon as possible after initiating an emergency response action. The PM will have responsibility for notifying the client.

14.3 EMERGENCY RESPONSE CONTACTS

All personnel must know whom to notify in the event of an emergency situation, even though the FC/HSO has primary responsibility for notification. Table 3 lists the names and phone numbers for emergency response services and individuals.

Table 3. Emergency response contacts

CONTACT	TELEPHONE NUMBER
Emergency Numbers	
Ambulance	911
Police	911
Fire	911
Harborview Medical Center	(206) 323-3074
US Coast Guard Office Emergency General information	 (206) 286-5400 (206) 442-5295 UHF Channel 16
National Response Center	(800) 424-8802
US Environmental Protection Agency	(908) 321-6660
Washington State Department of Ecology – Northwest Region Spill Response (24-hour emergency line)	(206) 649-7000
Emergency Contacts	
Susan McGroddy, Project Manager	(206) 812-5421
Tad Deshler, Corporate Health and Safety Manager	(206) 812-5406
Helle Andersen, Field Coordinator/ Health and Safety Officer	(206) 353-9346 (site cellular telephone)

14.4 RECOGNITION OF EMERGENCY SITUATIONS

Emergency situations will generally be recognizable by observation. An injury or illness will be considered an emergency if it requires treatment by a medical professional and cannot be treated with simple first-aid techniques.

14.5 DECONTAMINATION

In the case of evacuation, decontamination procedures will be performed only if doing so does not further jeopardize the welfare of site workers. If an injured individual is also heavily contaminated and must be transported by emergency vehicle, the emergency response team will be informed of the type of contamination. To the extent possible, contaminated PPE will be removed but only if doing so does not exacerbate the injury. Plastic sheeting will be used to reduce the potential for spreading contamination to the inside of the emergency vehicle.

14.6 FIRE

Field personnel will attempt to control only small fires. If an explosion appears likely, personnel will follow evacuation procedures specified during the training session. If a fire cannot be controlled with the onboard fire extinguisher that is part of the required safety equipment, personnel will either withdraw from the vicinity of the fire or evacuate the boat as specified in the training session.

14.7 PERSONAL INJURY

In the event of serious personal injury, including unconsciousness, possibility of broken bones, severe bleeding or blood loss, burns, shock, or trauma, the first responder will immediately do the following:

- Administer first aid, if qualified.
- If not qualified, seek out an individual who is qualified to administer first aid, if time and conditions permit.
- Notify the PEC of the incident, the name of the individual, the location, and the nature of the injury.

The PEC will immediately do the following:

- Notify the boat captain and the appropriate emergency response organization.
- Assist the injured individual(s).
- Follow the emergency procedures for retrieving or disposing of equipment and leave the site and proceed to the predetermined land-based emergency pick-up.
- Designate someone to accompany the injured individual to the hospital.
- If a life-threatening emergency occurs (i.e., injury in which death is imminent without immediate treatment), the PEC or boat captain will call 911 and arrange to meet the emergency responder at the nearest accessible location or dock. For injuries or emergencies that are not life-threatening (i.e., broken bones, minor lacerations), the PEC will follow the procedures outlined above and proceed to the Harbor Island Marina or to an alternative location if that would be more expedient.
- Notify the HSM and the PM.

If the PEC determines that emergency response is not necessary, she may direct someone to decontaminate and transport the individual by vehicle to the nearest hospital. Directions describing the route to the hospital are in Section 14.10.

If a worker leaves the to seek medical attention, another worker should accompany that person to the hospital. When in doubt about the severity of an injury or exposure, always seek medical attention as a conservative approach and notify the PEC.

The PEC will be responsible for completing all accident/incident field reports, OSHA Form 200s, and other required follow-up forms.

14.8 OVERT PERSONAL EXPOSURE OR INJURY

If an overt exposure to toxic materials occurs, the first responder to the victim will initiate actions to address the situation. The following actions should be taken, depending on the type of exposure.

14.8.1 Skin contact

- Wash/rinse the affected area thoroughly with copious amounts of soap and water.
- If eye contact has occurred, eyes should be rinsed for at least 15 minutes using the eyewash that is part of the onboard emergency equipment.
- After initial response actions have been taken, seek appropriate medical attention.

14.8.2 Inhalation

- Move victim to fresh air.
- Seek appropriate medical attention.

14.8.3 Ingestion

- Seek appropriate medical attention.

14.8.4 Puncture wound or laceration

- Seek appropriate medical attention.

14.9 SPILLS AND SPILL CONTAINMENT

No bulk chemicals or other materials subject to spillage are expected to be used during this project. Accordingly, no spill containment procedure is required for this project.

14.10 EMERGENCY ROUTE TO THE HOSPITAL

The name, address, and telephone number of the hospital that will be used to provide medical care is as follows:

Harborview Medical Center
325 Ninth Avenue
Seattle, WA
(206) 323-3074

Directions from the vicinity of EW to Harborview Medical Center are as follows:

- Dock the vessel at the First Avenue S boat launch.
- Drive east on S River Street.

- Turn left on Occidental Avenue S.
- Turn left on E Marginal Way S.
- Turn right on S Michigan Street.
- Look for entrance ramps to I-5 northbound.
- Head north on I-5.
- Take the James Street exit.
- Head east on James Street to Ninth Avenue.
- Turn right on Ninth Avenue.
- Emergency entrance will be two blocks south on the right.

15 References

PSEP. 1997. Recommended guidelines for sampling marine sediment, water column, and tissue in Puget Sound. Final Report. Prepared for the U.S. Environmental Protection Agency, Seattle, Washington, and the Puget Sound Water Quality Action Team, Olympia, WA.

Attachment 1. Field Team Health and Safety Plan Review

I have read a copy of the Health and Safety Plan, which covers field activities that will be conducted to investigate potentially contaminated areas in the EW. I understand the health and safety requirements of the project, which are detailed in this Health and Safety Plan.

Signature	Date
Signature	Date
Signature	Date
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Signature	Date

APPENDIX B

Field Collection Forms

Windward environmental LLC

BENTHIC TISSUE FORM

AREA	DATE	TIME	GRAB #	INVERTEBRATE WEIGHT(g)	CLAM (>2cm) MASS (g)

SURFACE SEDIMENT COLLECTION FORM

Project Name: ______________________ **Project no.** ______________________

Date: ______________________ **Station:** ______________________

Start/Stop time: ______________________ ______________________

Sampling Method: ______________________ ______________________

Weather: ____

Crew: ____

SampleID: __________ **Bottom depth:** __________ **Penetration depth** __________ **Time:** __________

Analyses needed before homogenization (circle): **VOC** **sulfides** **AVS/SEM** | **Acceptable grab (circle)** **yes** **no**

Sediment type:	**Sediment color:**	**Sediment odor:**		**Comments:**
cobble	drab olive	none	H_2S	
gravel	gray	slight	petroleum	
sand C M F	black	moderate	other:	
silt clay	brown	strong		
organic matter	brown surface			

SampleID: __________ **Bottom depth:** __________ **Penetration depth** __________ **Time:** __________

Analyses needed before homogenization (circle): **VOC** **sulfides** **AVS/SEM** | **Acceptable grab (circle)** **yes** **no**

Sediment type:	**Sediment color:**	**Sediment odor:**		**Comments:**
cobble	drab olive	none	H_2S	
gravel	gray	slight	petroleum	
sand C M F	black	moderate	other:	
silt clay	brown	strong		
organic matter	brown surface			

SampleID: __________ **Bottom depth:** __________ **Penetration depth** __________ **Time:** __________

Analyses needed before homogenization (circle): **VOC** **sulfides** **AVS/SEM** | **Acceptable grab (circle)** **yes** **no**

Sediment type:	**Sediment color:**	**Sediment odor:**		**Comments:**
cobble	drab olive	none	H_2S	
gravel	gray	slight	petroleum	
sand C M F	black	moderate	other:	
silt clay	brown	strong		
organic matter	brown surface			

SampleID: __________ **Bottom depth:** __________ **Penetration depth** __________ **Time:** __________

Analyses needed before homogenization (circle): **VOC** **sulfides** **AVS/SEM** | **Acceptable grab (circle)** **yes** **no**

Sediment type:	**Sediment color:**	**Sediment odor:**		**Comments:**
cobble	drab olive	none	H_2S	
gravel	gray	slight	petroleum	
sand C M F	black	moderate	other:	
silt clay	brown	strong		
organic matter	brown surface			

PROTOCOL MODIFICATION FORM

Project Name and Number: _____

Material to be Sampled: _____

Measurement Parameter: _____

Standard Procedure for Field Collection & Laboratory Analysis (cite reference):

Reason for Change in Field Procedure or Analysis Variation: _____

Variation from Field or Analytical Procedure: _____

Special Equipment, Materials or Personnel Required: _____

Initiator's Name: _____ Date: _____

Project Manager: _____ Date: _____

QA Manager: _____ Date: _____

APPENDIX C

Risk-Based Analytical Concentration Goals for Benthic Tissue

Appendix C Risk-Based Analytical Concentration Goals for Benthic Tissue

C-1 RBC Derivation for the Protection of Fish

RBCs derived for the protection of fish are expressed as chemical concentrations in the prey of the fish for those chemicals evaluated using a dietary approach in the ERA (i.e., PAHs and metals, except mercury). RBCs are expressed as concentrations in fish prey for these chemicals because they are metabolized or otherwise regulated by fish. RBCs derived in prey tissue for the protection of fish will be considered in the determination of ACGs for the market basket benthic invertebrate tissue samples described in this QAPP.

RBCs for fish represent chemical concentrations in fish prey independent of prey type. English sole consume primarily benthic invertebrates, brown rockfish consume both shrimp, crabs and fish, and juvenile chinook salmon consume both benthic invertebrates and terrestrial insects. Because it is not known what percentages of fish diets are represented by different types of prey, or what the chemical concentrations would be in the different prey items, the RBC for the protection of fish is assumed to be the same whether it is applied to benthic invertebrate tissue or other fish prey types. Thus, a single RBC will be applicable for all fish species regardless of their diet and is relevant in setting the ACG for all tissue types consumed by fish.

RBCs for other chemicals to be evaluated for fish in the ERA, such as PCBs, mercury, DDT, and TBT, were presented in the fish and crab tissue QAPP, and will be determined using a critical tissue residue approach (i.e., RBCs will be expressed as chemical concentrations in fish tissue, not their prey).

To derive RBCs for the protection of fish for this QAPP, toxicity data were reviewed for effects of PAHs and metals (other than mercury) on fish species, and NOECs and LOECs in fish food were identified. Effects endpoints considered were growth, reproduction, and survival.

The NOECs and LOECs derived from the literature are expressed as chemical concentrations in fish food in units of mg/kg ww. Table C-1 summarizes RBCs for fish, based on both NOECs and LOECs, if available. The NOEC-based RBC is the most relevant concentration; LOEC-based RBCs are presented in case the NOEC-based RBC is less than the MDL. Table D-1 presents summary information for the studies selected to derive RBCs in fish prey items. The summary information in Table D-1 includes the endpoint, test species, exposure pathway, and reference for each NOEC and LOEC shown. The following sections describe the literature search process and the derivation of RBCs for the protection of fish.

Table C-1. Studies selected to derive RBCs in prey items of fish

Analyte	NOEC (mg/kg ww)	LOEC (mg/kg ww)	Endpoint	Test Species	Exposure Pathway	Reference
Arsenic	7.76[a]	10.4[a]	growth	rainbow trout	food	Hocket et al. 2003
Cadmium	na	17.26[b]	growth	guppy	food	Hatakeyama and Yasuno 1982
Cadmium	22.8[a]	na	growth	rainbow trout	food	Erickson et al. 2003
Copper	61.6[a]	na	growth	rainbow trout	food	Erickson et al. 2003
Lead	6,336[c]	na	growth	rainbow trout	food	Goettl et al. 1976
Selenium	3.5	6.6	mortality	bluegill juveniles	food	Cleveland et al. 1993
Silver	2,700[c]	na	growth	rainbow trout	food	Galvez and Wood 1999
Zinc	na	1,800[c]	growth	rainbow trout	food	Takeda and Shimma 1977
Zinc	380[a]	na	growth	rainbow trout	food	Mount et al. 1994
Benzo(a)pyrene	6.58[d]	16.24[d]	growth	English sole	food	Rice et al. 2000

na – NOAEL or LOAEL not available or not applicable based on the selection criteria discussed in Section C.2.2

Note: Conversions to wet weight were based on type of food or prey species used in each study.

[a] Converted to wet weight assuming 20% solids in prey (a typical solids content in aquatic organisms)

[b] Converted to wet weight using measured 13.7% solids in midge prey from a separate study (Hatakeyama and Yasuno 1987)

[c] Converted to wet weight assuming 90% solids in prepared food (Palm et al. 2003)

[d] Converted to wet weight assuming 14% solids in *Armandia brevis* (Windward unpublished data)

C-2 RBC Derivation for the Protection of Benthic Invertebrates

PCBs

Seven studies (Boese et al. 1995; Duke et al. 1970; Hansen et al. 1974b; Lowe et al. 1972; Nimmo et al. 1974; Peterson et al. 1994; Sanders and Chandler 1972) evaluated the adverse effects of PCBs on decapods or mollusks. The lowest LOAEL was 1,100 µg/kg ww, reported for Aroclor 1016.

TBT

Potential effects from TBT exposure on survival, growth, and reproduction of benthic invertebrates were also evaluated using a critical tissue-residue approach. Excluding studies involving the imposex endpoint for gastropods, which was addressed through direct measurement of the imposex endpoint as discussed in Section A.3.2.4.1 above, five studies were identified that reported tissue concentrations of TBT associated with adverse effects (Table D-2). The LOAELs for effects on growth and reproduction ranged from 2.36 to 5.44 mg/kg dw. The lowest LOAEL (2.36 mg/kg dw) was selected as the TRV because of the relevance of the sediment exposure as well as the polychaete growth endpoint. The juvenile polychaetes exhibited a reduction in growth of 25% relative to the control sediment at a TBT concentration of 101 ng/g dw in sediment, which resulted in a tissue concentration of 2.36 mg/kg dw (Meador and Rice 2001). The associated NOAEL of 0.97 mg/kg dw was the only NOAEL below the LOAEL.

Table C-2. TBT critical tissue-residue toxicity studies for benthic invertebrates

Test Species	NOAEL mg/kg dw)	LOAEL (mg /kg dw)	Effect	Exposure Conditions	Source
Polychaete (*Armandia brevis*)	0.97	2.36	reduced growth	sediment 42 days	Meador and Rice (2001)
Polychaete (*Neanthes arenaceodentata*)	2.99	6.27	impaired reproduction	aqueous 10 weeks	Moore et al. (1991)
Blue mussel (*Mytilus edulis)*	3.96	5.44	reduced growth	aqueous 4 days	Widdows and Page (1993)
Amphipod (*Hyalella azteca*)	na	32	reduced survival (LC50)	aqueous 10 days	Borgmann et al. (1996)
Polychaete (*Armandia brevis*)	na	41	reduced survival (LC50)	aqueous 10 days	Meador (1997)
Amphipod (*Eohaustorius estuarius*)	na	59	reduced survival (LC50)	aqueous 10 days	Meador (1997)
Amphipod (*Rhepoxynius abronius*)	na	54	reduced survival (LC50)	aqueous 10 days	Meador (1997)

dw – dry weight
LC50 – concentration that causes the death of 50% of a group of test animals
LOAEL – lowest-observed-adverse-effect level
na – not available
NOAEL – no-observed-adverse-effect level

Mercury

Tissue residue toxicity studies for mercury for benthic invertebrates are presented in Table D-3. These studies were reviewed for the Portland preliminary risk evaluation (PRE) and benthic invertebrates were limited to bivalves and decapods species.

Table C-3. Mercury critical tissue-residue toxicity studies for benthic invertebrates

Test Species	NOAEL mg/kg dw)	LOAEL (mg /kg dw)	Effect	Exposure Conditions	Source
gastropod- banded mystery snail	6[a]	-	mortality/ growth	aqueous 60 days	Tessier et al. 1996
slipper limpet	-	8[a]	growth/reproduction	aqueous 16 weeks	Thain 1984
marsh clam	-	12	mortality	aqueous 7 days	Widdows and Page (1993)

[a] Dry weight concentrations were converted to wet weight, assuming 80% moisture in the organism (wet weight concentration = 0.2 X dry weight concentration)

Comparison of target detection limits and ACGs

The ACGs are compared to the MDL and RL values in Table D-4. All detection limits are below the ACGs for both fish dietary exposure and benthic invertebrate tissue residue ACGs.

Table C-4. Comparison of target detection limits and ACGs

Method and Analyte	Detection Limits[a] (mg/kg ww)		ACGs (mg/kg ww)[b]			
			Fish Dietary exposure		Benthic Invertebrate Tissue	
	MDL	RL	LOEC-based	NOEC-based	LOEC-based	NOEC-based
EPA Method 8270D						
PAHs						
Acenaphthene	0.051	0.201	na	na	nd	nd
Acenaphthylene	0.051	0.201	na	na	nd	nd
Anthracene	0.051	0.201	na	na	nd	nd
Benzo(a)anthracene	0.051	0.201	na	na	nd	nd
Benzo(a)pyrene	0.051	0.201	16	6.6	nd	nd
Benzo(b)fluoranthene	0.051	0.201	na	na	nd	nd
Benzo(k)fluoranthene	0.051	0.201	na	na	nd	nd
Benzo(g,h,i)perylene	0.051	0.201	na	na	nd	nd
Chrysene	0.051	0.201	na	na	nd	nd
Dibenzo(a,h)anthracene	0.051	0.201	na	na	nd	nd
Dibenzofuran	0.051	0.201	na	na	nd	nd
Fluoranthene	0.051	0.201	na	na	nd	nd
Fluorene	0.051	0.201	na	na	nd	nd
Indeno(1,2,3-cd)pyrene	0.051	0.201	na	na	nd	nd

Method and Analyte	Detection Limits[a] (mg/kg ww)		ACGs (mg/kg ww)[b]			
			Fish Dietary exposure		Benthic Invertebrate Tissue	
	MDL	RL	LOEC-based	NOEC-based	LOEC-based	NOEC-based
1-Methylnaphthalene	0.051	0.201	na	na	nd	nd
2-Methylnaphthalene	0.051	0.201	na	na	nd	nd
Naphthalene	0.051	0.201	na	na	nd	nd
Phenanthrene	0.051	0.201	na	na	nd	nd
Pyrene	0.051	0.201	na	na	nd	nd
Total PAHs[d]	0.051	0.201	na	na	nd	nd
EPA Method 8082						
Aroclor 1016	0.0087	0.06	nd	nd	na	na
Aroclor 1221	0.0087	0.06	nd	nd	na	na
Aroclor 1232	0.0087	0.06	nd	nd	na	na
Aroclor 1242	0.0087	0.06	nd	nd	na	na
Aroclor 1248	0.0087	0.06	nd	nd	na	na
Aroclor 1254	0.0087	0.06	nd	nd	na	na
Aroclor 1260	0.0087	0.06	nd	nd	na	na
Total PCBs[c]	0.0087	0.06	nd	nd	1.1	na
EPA Method 6020, 6010B, or 7000						
Antimony	0.02	0.04	na	na	nd	nd
Arsenic	0.009	0.02	10	7.8	nd	nd
Cadmium	0.004	0.04	23	17	nd	nd
Chromium	0.06	0.1	na	na	nd	nd
Cobalt	0.008	0.2	na	na	nd	nd
Copper	0.058	0.5	na	62	nd	nd
Lead	0.078	1.0	na	6,336	nd	nd
Molybdenum	0.008	0.2	na	na	nd	nd
Nickel	0.11	0.5	na	na	nd	nd
Selenium	0.028	0.04	6.6	3.5	nd	nd
Silver	0.006	0.2	na	2,700	nd	nd
Thallium	0.011	0.02	na	na	nd	nd
Vanadium	0.034	0.2	na	na	nd	nd
Zinc	0.44	4.0	1,800	380	nd	nd
EPA Method 7471A						
Mercury	0.005	0.01	nd	nd	8.0	6.0
TBT Method - Krone 1989						
Di-n-butyltin	0.0039	0.024	nd	nd	na	na
Tri-n-butyltin	0.0034	0.016	nd	nd	2.36	0.96

Note: Actual RLs and MDLs will vary based on the amount of sample volume used for each analysis, matrix interferences, and the analytical dilution.
MDLs and RLs in **bold** exceed an ACG.

[a] RLs and MDLs from Analytical Resources, Inc

[b] ACGs for each tissue type are the lowest of the dietary or critical tissue residue RBCs associated with that tissue type.

[c] RLs and MDLs for calculated totals are the highest of the RLs and MDLs for the individual components.

ACG – analytical concentration goal

MDL – method detection limit

RL – reporting limit

na – not available

nd – not determined

APPENDIX D

Analytical Concentration Goals for Sediment Collected at Clam Sampling Locations

Appendix D Risk-based Analytical Concentration Goals for Sediment

D.1 INTRODUCTION

This appendix addresses the following question:

> Are standard analytical methods proposed for the chemical analysis of sediment samples sufficiently sensitive to meet the needs of the East Waterway ecological and human health risk assessments?

To answer this question, standard laboratory reporting limits (RLs) and method detection limits (MDLs) were compared to analytical concentration goals (ACGs) for sediment. To determine ACGs for this quality assurance project plan (QAPP), sediment risk-based concentrations (RBCs) were identified or derived for the protection of benthic invertebrates and humans. RBCs in sediment are not relevant for other ecological receptors because sediment is generally a very small dietary component for the fish and other wildlife receptor species that will be evaluated in the ecological risk assessment (ERA). The risk-based ACGs for sediment are equal to the lowest RBC for each chemical. For example, if RBCs are identified or calculated for humans and benthic invertebrates for cadmium, the risk-based ACG for cadmium in sediment is set by the RBC for the receptor most sensitive to cadmium (the lowest of the two RBCs).

For the protection of benthic invertebrates, RBCs are defined as the concentration of a chemical in sediment corresponding to numerical criteria found in the Washington State Sediment Management Standards (SMS). The SMS include numerical criteria for 47 chemicals or groups of chemicals. The lowest numerical criterion for each chemical is called the Sediment Quality Standard (SQS). The Dredged Material Management Program (DMMP) also includes criteria for chemicals in sediment. The lowest guideline in that program is called the Screening Level (SL). RBCs are set equal to the SQS or to the SLs if no SQS is available for a given chemical.

Sediment RBCs are defined for the protection of wildlife receptors as the concentration of a chemical in sediment incidentally ingested by that receptor that is associated with no adverse effects on growth, reproduction, or survival.[1] For the protection of human health, RBCs are defined by two methods. In one method, which was applied to all chemicals, RBCs are defined as the concentration of a chemical in sediment incidentally ingested or directly contacted that has been identified as having an acceptable risk level (e.g., excess cancer risk of 10^{-6} or HQ less than 0.1 for non-cancer risk). In the other method, which was applied for chemicals likely to bioaccumulate in fish and shellfish

[1] The lowest concentration associated with adverse effects was used if data were not available for a concentration associated with no effects.

consumed by humans, sediment RBCs were based on a back-calculation[2] from clam tissue RBCs.

Sediment RBCs have not been developed by EPA Region 10 or Ecology for the protection of humans. Therefore human RBCs were calculated by reviewing human health guidance documents. Although information from the toxicological literature is used in this document, the objective of this memo is not to establish the toxicity reference values (TRVs) to be used for the ecological and human health risk assessments. The TRVs to be used in those assessments will be determined during in consultation with EPA.

The remainder of this appendix is organized as follows:

- Section C.2.0 – RBC derivation methods for benthic invertebrates and humans
- Section C.3.0 – Comparison of ACGs to RLs
- Tables C-1 through C-5 (located at the end of this appendix) summarize RBCs for all receptors for each chemical, provide background information for RBC selection, and compare ACGs and RLs.

D.2 RISK-BASED CONCENTRATIONS

For this QAPP, RBCs are sediment concentrations associated with an acceptable risk level as derived from state standards, the toxicity literature, or human health guidance documents. In this appendix, sediment RBCs are derived for the protection of the following receptors through several exposure pathways:

- Benthic invertebrates exposed to chemicals via direct contact with sediment
- Humans exposed to chemicals via direct contact or incidental ingestion of sediment
- Humans exposed to chemicals via seafood consumption

Sediment RBCs were calculated from clam tissue RBCs using a biota-sediment accumulation factor, as described in Windward (2004a). The clam tissue RBCs were calculated using the total seafood consumption rate rather than the consumption rate of clams. The following sections describe how RBCs were derived for each receptor. The specific chemicals for which RBCs were derived are discussed in the sections below for each receptor, and are summarized in Table D-1.

[2] Sediment RBCs were calculated from clam tissue RBCs using a biota-sediment accumulation factor, as described in Windward (2004a). The clam tissue RBCs were calculated using the total seafood consumption rate rather than the consumption rate of clams.

Table D-1. Receptor-specific RBCs for sediment

Analyte	Receptor-Specific RBC (mg/kg dw)		
	Human Health[a]		Benthic Invertebrates[b]
	Indirect Exposure	Direct Exposure	
Metals			
Antimony	na	**3.1**	150
Arsenic	**0.006**	0.39	57
Cadmium	**0.003**	7	5.1
Chromium	100	**23**	260
Cobalt	na	na	na
Copper	**1.3**	310	390
Lead	na[c]	**40**	450
Mercury	**0.016**	0.78	0.41
Molybdenum	na	**39**	na
Nickel	na[c]	160	**140**
Selenium	na[c]	**39**	na
Silver	na[c]	39	**6.1**
Thallium	na	**0.51**	na
Vanadium	na	**39**	na
Zinc	**16**	2,300	410
Organometals			
Tri-n-butyltin ion	**0.00028**	1.8	0.0085
PAHs			
2-Methylnaphthalene	1.7	31	**0.19**
Acenaphthylene	na	na	**0.33**
Acenaphthene	540	340	**0.080**
Anthracene	900	1,700	**1.1**
Benzo(a)anthracene	**0.0052**	0.15	0.55
Benzo(a)pyrene	**0.00076**	0.015	0.50
Benzo(b)fluoranthene	**0.0047**	0.15	na
Benzo(g,h,i)perylene	na	na	**0.16**
Benzo(k)fluoranthene	**0.047**	1.5	na
Total benzofluoranthenes	na	na	**1.2**
Chrysene	**0.48**	15	0.50
Dibenzo(a,h)anthracene	na[c]	**0.015**	0.06
Dibenzofuran	0.56	na	**0.075**
Fluoranthene	2.1	230	**0.80**
Fluorene	na[c]	230	**0.12**
Indeno(1,2,3-cd)pyrene	**0.0029**	0.15	0.17
Naphthalene	4.5	3.9	**0.50**
Phenanthrene	na	na	**0.50**
Pyrene	8.9	170	**5.0**
Total LPAHs	na	na	**1.9**
Total HPAHs	na	na	**4.8**
PCBs			
Aroclor 1016	**0.0061**	0.39	na
Aroclor 1221	**0.00021**	0.17	na

Analyte	Receptor-Specific RBC (mg/kg dw)		
	Human Health[a]		Benthic Invertebrates[b]
	Indirect Exposure	Direct Exposure	
Aroclor 1232	**0.00021**	0.17	na
Aroclor 1242	**0.00021**	0.22	na
Aroclor 1248	**0.00021**	0.22	na
Aroclor 1254	**0.00021**	0.22	na
Aroclor 1260	**0.00021**	0.22	na
Total PCBs	**0.00021**	na	0.06

NOTE: Values in **BOLD** were used as ACGs in Table D-5.

na – toxicity data not available or not applicable

[a] The RBC for a given chemical may be derived from either carcinogenic or non-carcinogenic endpoints. For chemicals with both endpoints, the lower RBC is shown.

[b] RBCs for benthic invertebrates are equivalent to the SQS/SL for chemicals with standards expressed on a dry weight basis. For chemicals with standards expressed on an organic-carbon normalized basis, an organic carbon content of 0.5% was assumed to convert the standards to dry weight.

[c] This chemical was identified as an important bioaccumulative chemical by EPA (2000), but no BSAF is available from the sources listed in Section D.2.2.2, so no RBC for indirect exposure was calculated.

[d] Dioxin-like PCB and dioxin/furan congeners will be evaluated as toxic equivalents (TEQs) in the risk assessments, rather than as individual congeners. However, because TEQs are calculated, rather than measured by the laboratory, RBCs for individual congeners are presented to facilitate comparison with RLs for those congeners. In reality, risks will be assessed based on sums of these congeners (normalized per their relative toxicity to TCDD), and thus comparison to RLs on a congener-specific basis is somewhat uncertain.

[e] RBCs for chlordane for human health are based on toxicity of mixtures of chlordane-related compounds (e.g., alpha- and gamma-chlordane, cis- and trans-nonachlor).

D.2.1 RBC derivation for the protection of benthic invertebrates

RBCs for the protection of benthic invertebrates are expressed as chemical concentrations in sediment, to which benthic invertebrates are directly exposed. The benthic invertebrate RBCs are derived from the SQS or from DMMP SLs when SQS are not available. There are 14 chemicals that have SLs but do not have an SQS value. The SQS and SL values are presented in Table D-2. The RBCs in Table D-1 for benthic invertebrates are equivalent to the SQS/SL for chemicals where the SQS is expressed on a dry weight basis. For chemicals with standards expressed on an organic-carbon (OC) normalized basis, a lower-than-average OC content of 0.5% was assumed to convert the SQS to its dry weight equivalent.

No sediment-based SQS or SL is available for TBT. The benthic invertebrate sediment RBC for TBT is calculated for the purposes of this appendix using a tissue effect value along with a modified bioaccumulation factor (BAF), as described below.

The tissue effect value was obtained from a review of effects data associated with TBT in benthic invertebrate tissues. The lowest LOEC (lowest-observed-effect concentration; the lowest concentration at which an adverse effect was observed) was 2.4 mg/kg dry weight (dw) associated with reduced growth of the polychaete *Armandia brevis* (Meador and Rice 2001). The highest NOEC (no-observed-effect concentration; the highest concentration at which no adverse effect was observed) found in a laboratory study was 0.85 mg/kg dw (reduced condition index in Pacific oysters, assuming a moisture

content of 80% (Davies et al. 1988)). The LOEC and NOEC are 0.48 and 0.17 mg/kg ww, respectively. The NOEC of 0.17 mg/kg ww was used as the tissue effect concentration for calculating the RBC only for the purposes of this appendix (the NOECs and LOEC to be used in the EW remedial investigation will be developed as part of the Phase 2 ERA).

The modified bioaccumulation factor was derived as described in the using a wet weight tissue concentration and a sediment concentration expressed on an organic carbon-normalized basis, as follows:

$$\text{Modified BAF for TBT} = \frac{\text{Biota (mg/kg ww)}}{\text{Sediment (mg/kg OC)}} \qquad \textbf{Equation 1}$$

The modified BAF used in this appendix is 0.10 (Windward, 2003). The sediment RBC was then calculated using Equation 2:

$$\text{Sediment (mg/kg dw)} = \frac{\text{Tissue effect concentration (mg/kg ww)}}{\text{Modified BAF for TBT}} \times 0.5\%\text{OC in sediment} \times 0.01$$

Equation 2

Using this approach, the sediment RBC for benthic invertebrates for TBT is 0.0085 mg/kg dw (Table D-1).

Table D-2. Chemical criteria used to derive sediment RBCs for benthic invertebrates

CHEMICAL	UNIT	SQS	SL
Metals			
Antimony	mg/kg dw	ns	150
Arsenic	mg/kg dw	57	sa
Cadmium	mg/kg dw	5.1	sa
Chromium	mg/kg dw	260	sa
Copper	mg/kg dw	390	sa
Lead	mg/kg dw	450	sa
Mercury	mg/kg dw	0.41	sa
Nickel	mg/kg dw	ns	140
Silver	mg/kg dw	6.1	sa
Zinc	mg/kg dw	410	sa
PAHs			
2-Methylnaphthalene	mg/kg OC	38	sa
Acenaphthene	mg/kg OC	16	sa
Acenaphthylene	mg/kg OC	66	sa
Anthracene	mg/kg OC	220	sa
Benzo(a)anthracene	mg/kg OC	110	sa
Benzo(a)pyrene	mg/kg OC	99	sa
Benzo(g,h,i)perylene	mg/kg OC	31	sa
Total benzofluoranthenes	mg/kg OC	230	sa
Chrysene	mg/kg OC	110	sa
Dibenzo(a,h)anthracene	mg/kg OC	12	sa
Dibenzofuran	mg/kg OC	15	sa

CHEMICAL	UNIT	SQS	SL
Fluoranthene	mg/kg OC	160	sa
Fluorene	mg/kg OC	23	sa
Indeno(1,2,3-cd)pyrene	mg/kg OC	34	sa
Naphthalene	mg/kg OC	99	sa
Phenanthrene	mg/kg OC	100	sa
Pyrene	mg/kg OC	1,000	sa
Total HPAHs	mg/kg OC	960	sa
Total LPAHs	mg/kg OC	370	sa
Polychlorinated biphenyls			
Total PCB Aroclors	mg/kg OC	12	sa

OC – organic carbon
dw – dry weight
ns – SQS not available
sa – SQS available and used as the preferred criterion

D.2.2 RBC derivation for the protection of humans

RBCs for the protection of human health were derived for both direct and indirect (i.e., seafood consumption) exposure pathways and are presented in Table D-1. For non-bioaccumulative chemicals, RBCs were calculated for direct exposure pathways, as described in Section D.2.2.1. For bioaccumulative chemicals, RBCs were calculated for the seafood consumption pathway, as described in Section D.2.2.2. Bioaccumulative compounds were identified by EPA (2000).

D.2.2.1 Direct sediment exposure pathway

RBCs for the protection of humans that may directly contact or incidentally ingest sediment are expressed as chemical concentrations in sediment. Human health guidance documents were reviewed for RBCs for human health. Oak Ridge National Laboratory (ORNL) presents RBCs for the protection of human health from exposures to soil that have been agreed upon by EPA Regions 3, 6, and 9 (ORNL 2008). The Model Toxics Control Act (MTCA, a Washington State statute) also includes RBCs for soil, but they are generally higher than the ORNL RBCs because of different exposure parameters. Consequently, ORNL RBCs were used instead of MTCA RBCs because they are more health protective and because they represent the best available science agreed upon by three EPA regional offices. The soil RBCs represent very conservative ACGs for East Waterway (EW) sediments because they are based on residential soil exposure scenarios at a target HQ of 0.1.

ORNL (ORNL 2008) contains soil RBCs for both industrial and residential scenarios. Residential RBCs were used in this appendix because they are more health protective than the industrial RBCs. ORNL RBCs for chemicals with noncarcinogenic effects were decreased by a factor of 10 to account for the target hazard quotients of 0.1 used in

screening by EPA Region 10.[3] ACGs can be calculated for chemicals with either carcinogenic or non-carcinogenic endpoints; some chemicals have both types of endpoints. For chemicals with both endpoints, the lower ACG is shown in Table D-5.

D.2.2.2 Indirect sediment exposure pathway

RBCs for the indirect sediment exposure pathway (i.e., seafood consumption) require that a relationship be developed between chemical concentrations in tissue and sediment. One commonly used method for evaluating such a relationship for nonpolar organic chemicals that may bioaccumulate is the biota sediment accumulation factor (BSAF).

BSAFs can be derived using Equation 4:

$$BSAF = \frac{C_{WB} \div F_L}{C_{sed} \div F_{oc}} \qquad \textbf{Equation 4}$$

where:

C_{WB}	=	chemical concentration in whole-body tissue (mg/kg ww)
C_{sed}	=	chemical concentration in sediment (mg/kg dw)
F_L	=	fraction lipid in tissue (kg lipid/kg ww)
F_{oc}	=	fraction organic carbon in sediment (kg OC/kg dw)

A key variable in the BSAF equation is the sediment concentration (C_{sed}). The BSAF equation is based on the assumption that C_{sed} represents the average chemical concentration in sediment to which the organism is exposed. For animals with very small home ranges, such as clams, this assumption may be reasonable if sediment data are collected concurrently with tissue data at the tissue collection locations. For animals with larger home ranges, such as fish, there is greater uncertainty in this assumption because many fish are highly mobile and are not likely to inhabit all areas of their home range with equal frequency. Consequently, fish BSAFs for a given chemical may easily range over at least an order of magnitude (USACE 2003).

Equation 4 can be rearranged to solve for C_{sed}, as follows:

$$C_{sed} = \frac{(C_{WB} \div F_L) \times F_{oc}}{BSAF} \qquad \textbf{Equation 5}$$

For this appendix, the C_{WB} based on 98 g/day was used in Equation 5. More details on calculation of chemical concentrations in tissue, including for chemicals with toxic equivalency factors can be found in Appendix C. The BSAFs used to calculate ACGs for sediment (i.e., C_{sed} in Equation 5) were from four sources:

[3] EPA Region 10 recommends a target hazard quotient of 0.1; therefore, the EPA Region 9 RBCs (which are based on a target hazard quotient of 1) have been adjusted by dividing by 10 for the ACG.

- US Army Corps of Engineers Environmental Residue-Effects Database (ERED) - http://www.wes.army.mil/el/ered/
- Tracey GA, Hansen DJ. 1996. Use of biota-sediment accumulation factors to assess similarity of nonionic organic chemical exposure to benthically-coupled organisms of differing trophic mode. Arch Environ Contam Toxicol 30:467-475.
- EPA. 1997. The incidence and severity of sediment contamination in surface waters of the United States. Volume 1: National Sediment Quality Survey. EPA 823-R-97-006. US Environmental Protection Agency, Office of Science and Technology, Washington, DC.
- Washington State Department of Health. 1995. Tier I report, development of sediment quality criteria for the protection of human health. Washington State Department of Health, Olympia, Washington.

The BSAFs cited in these four sources will not necessarily be used for any other purpose in the EW RI other than developing sediment ACGs in this appendix. BSAFs for bivalve mollusks are most appropriate for the ACG calculation, as described above. However, some fish BSAFs were used in this appendix when bivalve BSAFs were not available (i.e., some SVOCs and 2,3,7,8-TCDD).

D.3 COMPARISON OF ACGS TO RLS

ACGs were determined for sediment by selecting the lowest RBC for each chemical from Table D-1. These ACGs for sediment were compared with RLs, which represent the minimum analyte concentrations that can be reliably quantified, and with MDLs, which are lower than the RL and represent the minimum analyte concentration that can be detected with 99% confidence.

As shown in Table D-5, all ACGs are higher than the target RLs and MDLs, with the exception of five PAHs (benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-c,d)pyrene), six PCB Aroclors, total PCBs, three metals (arsenic, cadmium, mercury), and tributyltin. When the ACGs for these analytes are compared with the target MDLs, ACGs for 13 of these chemicals are higher than the target MDL, indicating that the test methods should be sufficiently sensitive to detect these chemicals at concentrations above the ACGs. Fourteen chemicals have ACGs lower than both their target RL and MDL (six Aroclors, total PCBs, four PAHs, , tributyltin, arsenic, and cadmium).

Four PAHs listed above with target MDLs or RLs greater than the ACG, as well as cadmium, mercury, tributyltin, Aroclor 1260 and total PCBs were detected in over 80% of the historical surface sediment samples using standard test methods with comparable target RLs. Arsenic, dibenzo(a,h)anthracene, and Aroclor 1254 were detected in over 50% of the historical sediment samples (68%, 54%, and 68%, respectively). Based on these historical results, the PAHs, PCBs, and metals listed above are also likely to be

detected in most or all the sediment samples described in this QAPP. Consequently, the fact that the ACGs are lower than both the MDL and RL should not compromise the quality of the data to be used in the risk assessments for these chemicals.

The MDLs and RLs for Aroclor 1242, and Aroclor 1248 are higher than the respective ACGs. These chemicals were detected in 2 to 28% of the historical sediment samples. For the undetected chemicals with RLs above the ACGs, the ramifications for the HHRA and ERA will be discussed in the uncertainty assessments.

The laboratories will make all reasonable efforts to achieve the target MDLs and RLs for all chemicals. Additional efforts may include modified extraction techniques (e.g., extracting a higher sample volume or adjusting the final extract volume), sample cleanup procedures (e.g., gel-permeation column chromatography), using a lower concentration for the lowest standard in the initial calibration, or adjusting the amount of extract injected into the instrument. If no PCB Aroclors are detected in a sample, a low-level extraction technique may be performed.

Table D-5. Comparison of sediment ACGs to target RLs and MDLs

Chemical	MDL[a]	RL[a]	Sediment ACG[b]
Metals (EPA 6020/7471A)			
Antimony	0.013	0.2	3.1
Arsenic	**0.17**	**0.5**	0.006
Cadmium	**0.016**	**0.2**	0.003
Chromium	0.136	0.5	23
Cobalt	0.008	0.2	na
Copper	0.043	0.5	1.3
Lead	0.078	1.0	40
Mercury	0.005	**0.05**	0.016
Molybdenum	0.008	0.2	39
Nickel	0.111	0.5	140
Selenium	0.671	2	39
Silver	0.006	0.2	6.1
Thallium	0.005	0.2	0.51
Vanadium	0.034	0.2	39
Zinc	0.443	4.0	16
Organometals (Krone 1989)			
Tri-n-butyltin ion	**0.0012**	**0.0040**	0.00028
PAHs (EPA 8270D)			
2-Methylnaphthalene	0.0082	0.020	0.19
Acenaphthylene	0.0087	0.020	0.33
Acenaphthene	0.0082	0.020	0.08
Anthracene	0.0077	0.020	1.1
Benzo(a)anthracene	**0.0059**	**0.020**	0.0052
Benzo(a)pyrene	**0.0082**	**0.020**	0.00076
Benzo(b)fluoranthene	**0.0095**	**0.020**	0.0047
Benzo(g,h,i)perylene	0.0068	0.020	0.16
Benzo(k)fluoranthene	0.0093	0.020	0.047

Chemical	MDL[a]	RL[a]	Sediment ACG[b]
Total benzofluoranthenes[c]	0.0095	0.020	1.2
Chrysene	0.0066	0.020	0.48
Dibenzo(a,h)anthracene	0.0086	**0.020**	0.015
Dibenzofuran	0.0076	0.020	0.075
Fluoranthene	0.0079	0.020	0.80
Fluorene	0.0090	0.020	0.12
Indeno(1,2,3-cd)pyrene	**0.0086**	**0.020**	0.0029
Naphthalene	0.0087	0.020	0.50
Phenanthrene	0.0084	0.020	0.50
Pyrene	0.0078	0.020	5.0
Total LPAHs[d]	0.0090	0.020	1.9
Total HPAHs[e]	0.0095	0.020	4.8
PCBs			
Aroclor 1016	0.0013	0.0040	0.0061
Aroclor 1221	**0.0013**	**0.0040**	0.00021
Aroclor 1232	**0.0013**	**0.0040**	0.00021
Aroclor 1242	**0.0028**	**0.0040**	0.00021
Aroclor 1248	**0.0028**	**0.0040**	0.00021
Aroclor 1254	**0.0028**	**0.0040**	0.00021
Aroclor 1260	**0.0028**	**0.0040**	0.00021
Total PCBs[f]	**0.0028**	**0.0040**	0.00021

RLs and MDLs in **BOLD** are greater than at least one of their respective ACGs.

na – not available

[a] Target RLs and MDLs are the most recent values provided by ARI and Analytical Perspectives. Actual RLs and MDLs will vary based on amount of sample analyzed, matrix interferences, analytical dilution, percent solids of the sample and/or updates to RLs and MDLs by the laboratory. The MDLs provided for PCB and dioxin congeners are the average MDLs of sample-specific detection limits, calculated from specific samples over 4-6 years

[b] ACG for sediment is the lowest of the RBCs for benthic invertebrates and humans.

[c] Total benzofluoranthenes is the sum of benzo(b)fluoranthene and benzo(k)fluoranthene. RL and MDL are the highest of the RLs and MDLs for benzo(b)fluoranthene or benzo(k)fluoranthene.

[d] Total LPAHs is the sum of naphthalene, 2-methyl naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene. RL and MDL are the highest RL and MDL for the LPAHs.

[e] Total HPAHs is the sum of fluoranthene, pyrene, benz(a)anthracene, chrysene, benzo(k)fluoranthene, benzo(b)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, dibenz(a,h)anthracene, and benzo(g,h,i)perylene. RL and MDL are the highest RL and MDL for the HPAHs.

[f] Total PCBs is the sum of the Aroclors. RL and MDL are the highest RL and MDL for the individual Aroclors.

D.4 REFERENCES

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APPENDIX E

Data Management

Appendix E Data Management

AVERAGING LABORATORY REPLICATE SAMPLES

Chemical concentrations obtained from the analysis of laboratory replicate samples (two or more analyses of the same sample) will be averaged for a closer representation of the "true" concentration as compared to the result of a single analysis. Averaging rules are dependent on whether the individual results are detected concentrations or reporting limits (RLs) for undetected chemicals. If all concentrations are detected for a single chemical, the values are simply averaged arithmetically for the sample and its associate laboratory replicate sample(s). If all concentrations are undetected for a given parameter, the minimum RL is selected. If the concentrations are a mixture of detected concentrations and RLs, any two or more detected concentrations are averaged arithmetically and RLs ignored. If there is a single detected concentration and one or more RLs, the detected concentration is reported. The latter two rules are applied regardless of whether the RLs are higher or lower than the detected concentration.

LOCATION AVERAGING

Results of chemical concentrations of discrete samples collected at a single sampling location that are submitted to the laboratory as individual samples and analyzed separately will be averaged for the purposes of mapping a single concentration per location. The averaging rules used for location averaging are the same as for laboratory replicate samples described above. This type of averaging is performed when multiple sediment samples are collected from the same location at the same time. For example: a sample and its field duplicate sample, often referred to as a split sample (PSEP 1997).

SIGNIFICANT FIGURES AND CALCULATIONS

Analytical laboratories report results with various numbers of significant figures depending on the laboratory's standard operating procedures, the instrument, the chemical, and the reported chemical concentration relative to the RL. The reported (or assessed) precision of each result is explicitly stored in the project database by recording the number of significant figures. Tracking of significant figures is used when calculating analyte sums and performing other data summaries. When a calculation involves addition, such as totaling PCBs, the calculation can only be as precise as the least precise number that went into the calculation. For example:

> 210 + 19 = 229 would be reported as 230 because although 19 is reported to 2 significant digits, the trailing zero in the number 210 is not significant.

When a calculation involves multiplication or division, the final result is rounded at the end of the calculation to reflect the value used in the calculation with the fewest significant figures. For example:

59.9 × 1.2 = 71.88 would be reported as 72 because there are two significant figures in the number 1.2.

When rounding, if the number following the last significant figure is less than 5, the digit is left unchanged. If the number following the last significant figure is equal to or greater than 5, the digit is increased by 1.

Many of the Washington State Sediment Management Standards (SMS) chemical criteria are in units normalized to the TOC content in the sediment sample (i.e., milligrams per kilogram organic carbon [mg/kg OC]). Only samples with TOC concentrations greater than or equal to 0.5% or less than or equal to 4.0% are considered appropriate for OC normalization. Samples with TOC concentrations less than 0.5% or greater than 4.0% are compared to dry weight chemical criteria. Chemical concentrations originally in units of micrograms per kilogram (µg/kg) dry weight were converted to mg/kg OC using the following equation:

$$\frac{(C_{\mu g/kg\ dry\ weight}) \times (0.001\ mg/\mu g)}{TOC}$$

Where:

C	=	the chemical concentration
TOC	=	the percent total organic carbon on a dry weight basis, expressed as a decimal (e.g., 1% = 0.01)

BEST RESULT SELECTION FOR MULTIPLE RESULTS

In some instances, the laboratory generates more than one result for a chemical for a given sample. Multiple results can occur for several reasons, including: 1) the original result did not meet the laboratory's internal quality control (QC) guidelines, and a reanalysis was performed; 2) the original result did not meet other project data quality objectives, such as a sufficiently low RL, and a reanalysis was performed; or 3) two different analytical methods were used for that chemical. In each case, a single best result is selected for use. The procedures for selecting the best result differ depending on whether a single or multiple analytical methods are used for that chemical.

For the same analytical method, if the results are:

- Detected and not qualified, then the result from the lowest dilution is selected, unless multiple results from the same dilution are available, in which case, the result with the highest concentration is selected.
- A combination of estimated and unqualified detected results, then the unqualified result is selected. This situation most commonly occurs when the original result is outside of calibration range, thus requiring a dilution.
- All estimated, then the "best result" is selected using best professional judgment in consideration of the rationale for qualification. For example, a result qualified based on laboratory replicate results outside of QC objectives

for precision would be preferred to a qualified result that is outside the calibration range.

- A combination of detected and undetected results, then the detected result is selected. If there is more than one detected result, the applicable rules for multiple results (as discussed above) are followed.
- All undetected results, then the lowest RL is selected.

If the multiple results are from different analytical methods, then the result from the preferred method specified in the quality assurance project plan (QAPP) or based on the consensus of the professional opinions of project chemists was selected.

The following rules are applied to multiple results from different analytical methods:

- For detected concentrations analyzed by the SVOC full-scan and selective ion monitoring (SIM) methods (i.e., PAHs), the highest detected concentration is selected. If the result by one method is detected and the result by the other method is not detected, then the detected result is selected for reporting, regardless of the method. If results are reported as non-detected by both methods, the undetected result with the lowest RL is selected. The SIM method is more analytically sensitive than the full-scan SVOC method, and the undetected results are generally reported at a lower RL by the SIM method than by the full-scan method. Therefore, the SIM method is selected for non-detected results unless an analytical dilution or analytical interferences elevated the SIM RL above the SVOC full-scan RL.
- Hexachlorobenzene and hexachlorocyclopentadiene are analyzed by EPA Methods 8081A, 8270, and/or 8270-SIM. The result from the method with the greatest sensitivity (i.e., lowest RL) is selected if all results are undetected. EPA Method 8081A results are generally selected, when available, because the standard laboratory RLs from this analysis are significantly lower than those from EPA Methods 8270 and 8270-SIM. When chemicals are detected, the detected result with the highest concentration is selected unless the detected concentration is qualified as estimated or tentatively identified, in which case the rule designating treatment of qualified and unqualified data would apply.

CALCULATED TOTALS

Total PCBs, total dichloro-diphenyl-trichloroethane (DDTs), total PAHs, and total chlordane are calculated by summing the detected values for the individual components available for each sample. For individual samples in which none of the individual components is detected, the total value is given a value equal to the highest RL of an individual component, and assigned the same qualifier (U or UJ), indicating an undetected result. Concentrations for the analyte sums are calculated as follows:

- **Total PCBs** are calculated, in accordance with the methods of the SMS, using only detected values for seven Aroclor mixtures.[1] For individual samples in which none of the seven Aroclor mixtures is detected, total PCBs are given a value equal to the highest RL of the seven Aroclors and assigned a U-qualifier indicating the lack of detected concentrations.
- **Total low-molecular-weight PAHs (LPAHs), high-molecular-weight PAHs (HPAHs), PAHs, and benzofluoranthenes** are also calculated in accordance with the methods of the SMS. Total LPAHs are the sum of detected concentrations for naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene. Total HPAHs are the sum of detected concentrations for fluoranthene, pyrene, benzo(a)anthracene, chrysene, total benzofluoranthenes, benzo(a)pyrene, indeno(1,2,3,-c,d)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene. Total benzofluoranthenes are the sum of the b (i.e., benzo(b)fluoranthene), j, and k isomers. Because the j isomer is rarely quantified, this sum is typically calculated with only the b and k isomers. For samples in which all individual compounds within any of the three groups described above are undetected, the single highest RL for that sample represents the sum.
- **Total DDTs** are calculated using only detected values for the DDT isomers: 2,4'-DDD; 4,4'-DDD; 2,4'-DDE; 4,4'-DDE; 2,4'-DDT; and 4,4'-DDT. For individual samples in which none of the isomers are detected, total DDTs are given a value equal to the highest RL of the six isomers and assigned a U-qualifier, indicating the lack of detected concentrations.
- **Total chlordane** is calculated using only detected values for the following compounds: alpha-chlordane, gamma-chlordane, oxychlordane, cis-nonachlor, and trans-nonachlor. For individual samples in which none of these compounds is detected, total chlordane is given a value equal to the highest RL of the five compounds listed above and assigned a U-qualifier, indicating the lack of detected concentrations.

CALCULATION OF PCB CONGENER TEQS

PCB congener toxic equivalents (TEQs) are calculated using the World Health Organization (WHO) consensus toxic equivalency factor (TEF) values for fish, birds (Van den Berg et al. 1998), and mammals (Van den Berg et al. 2006) as presented in Table E-1. The TEQ is calculated as the sum of each congener concentration multiplied by the corresponding TEF value. When the congener concentration is reported as non-detected, then the TEF is multiplied by half the RL.

[1] Aroclors 1016, 1221, 1232, 1242, 1248, 1254, and 1260.

Table E-1. PCB congener TEF values

PCB Congener Number	TEF Value for Fish (unitless)	TEF Value for Birds (unitless)	TEF Value for Mammals (unitless)
77	0.0001	0.05	0.0001
81	0.0005	0.1	0.0003
105	<0.000005	0.0001	0.00003
114	<0.000005	0.0001	0.00003
118	<0.000005	0.00001	0.00003
123	<0.000005	0.00001	0.00003
126	0.005	0.1	0.1
156	<0.000005	0.0001	0.00003
157	<0.000005	0.0001	0.00003
167	<0.000005	0.00001	0.00003
169	0.00005	0.001	0.03
189	<0.000005	0.00001	0.00003

PCB – polychlorinated biphenyl
TEF – toxic equivalency factor

Calculation of Dioxin/Furan Congener TEQs

Dioxin/furan congener TEQs are calculated using the WHO consensus TEF values (Van den Berg et al. 2006) for mammals as presented in Table E-2. The TEQ is calculated as the sum of each congener concentration multiplied by the corresponding TEF value. When the congener concentration is reported as undetected, then the TEF is multiplied by half the RL.

Table E-2. Dioxin/Furan congener TEF values for mammals

Dioxin/Furan Congener	TEF Value (unitless)
1,2,3,4,6,7,8-Heptachlorodibenzofuran	0.01
1,2,3,4,6,7,8-Heptachlorodibenzo-*p*-dioxin	0.01
1,2,3,4,7,8,9-Heptachlorodibenzofuran	0.01
1,2,3,4,7,8-Hexachlorodibenzofuran	0.1
1,2,3,4,7,8-Hexachlorodibenzo-*p*-dioxin	0.1
1,2,3,6,7,8-Hexachlorodibenzofuran	0.1
1,2,3,6,7,8-Hexachlorodibenzo-*p*-dioxin	0.1
1,2,3,7,8,9-Hexachlorodibenzofuran	0.1
1,2,3,7,8,9-Hexachlorodibenzo-*p*-dioxin	0.1
1,2,3,7,8-Pentachlorodibenzofuran	0.03
1,2,3,7,8-Pentachlorodibenzo-*p*-dioxin	1
2,3,4,6,7,8-Hexachlorodibenzofuran	0.1
2,3,4,7,8-Pentachlorodibenzofuran	0.3
2,3,7,8-Tetrachlorodibenzofuran	0.1

DIOXIN/FURAN CONGENER	TEF VALUE (unitless)
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1
Octachlorodibenzofuran	0.0003
Octachlorodibenzo-p-dioxin	0.0003

TEF – toxic equivalency factor

CALCULATION OF CARCINOGENIC POLYCYCLIC AROMATIC HYDROCARBONS

Carcinogenic polycyclic aromatic hydrocarbons (cPAH) values are calculated using TEF values (California EPA 1994; Ecology 2001) based on the individual PAH component's relative toxicity to benzo(a)pyrene. TEF values are presented in Table E-3. The cPAH is calculated as the sum of each individual PAH concentration multiplied by the corresponding TEF value. When the individual PAH component concentration is reported as non-detected, then the TEF is multiplied by half the RL.

Table E-3. cPAH TEF values

cPAH	TEF VALUE (unitless)
Benzo(a)pyrene	1
Benzo(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(k)fluoranthene	0.1
Bibenz(a,h)anthracene	0.4
Indeno(1,2,3-cd)pyrene	0.1
Chrysene	0.01

cPAH – carcinogenic polycyclic aromatic hydrocarbon
TEF – toxic equivalency factor

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APPENDIX F

Gastropod Forms

Gastropod Field Collection Form

Project Name: _____ **Project no.** _____

Date: _____ **Location:** **X:**

Start/Stop time: _____ **Y:** _____

Sampling Method: _____ **Sample ID:** _____

Weather: _____ **Crew:** _____

Tow #	Coordinates	Number of Gastropods		Comments
1	**X:**	*N. mendicus:*		
	Y:	*A. gausapata:*		
		A. compacta:		
		Others:		
2	**X:**	*N. mendicus:*		
	Y:	*A. gausapata:*		
		A. compacta:		
		Others:		
3	**X:**	*N. mendicus:*		
	Y:	*A. gausapata:*		
		A. compacta:		
		Others:		
4	**X:**	*N. mendicus:*		
	Y:	*A. gausapata:*		
		A. compacta:		
		Others:		
5	**X:**	*N. mendicus:*		
	Y:	*A. gausapata:*		
		A. compacta:		
		Others:		
6	**X:**	*N. mendicus:*		
	Y:	*A. gausapata:*		
		A. compacta:		
		Others:		
7	**X:**	*N. mendicus:*		
	Y:	*A. gausapata:*		
		A. compacta:		
		Others:		
8	**X:**	*N. mendicus:*		
	Y:	*A. gausapata:*		
		A. compacta:		
		Others:		
9	**X:**	*N. mendicus:*		
	Y:	*A. gausapata:*		
		A. compacta:		
		Others:		
10	**X:**	*N. mendicus:*		
	Y:	*A. gausapata:*		
		A. compacta:		
		Others:		

Gastropod Imposex/Intersex Laboratory Form

Project Name: East Waterway SRI- Benthic Invertebrates **Project no.** 04-08-06-21

Date: **Analyst:**

Sample ID	Gastropod Species	Shell Height (cm)	Sex	Imposex/Intersex Stage	Penis Length (mm)	Comments

General Comments: